GLOBE Program in Niger

Hydrology Program

Introduction to this Chapter

This chapter is particularly interesting for students because all of the data collection can be performed entirely by the students themselves, including by Elementary School students.

Pick and choose the protocols that interest you and for which you have equipment, but as all of these protocols are accessible to students of all ages we encourage you to do as many as possible.

The order in which you do the lessons and the data collection protocols is up to you. Some teachers will prefer to teach the students about water before moving on to the actual testing, while other will want to get started with the data collection right away to capture the students' interest and to take as much data as possible and then go back and teach the lessons.

We suggest taking some time at the beginning of the unit to teach the data collection protocols so your school can start sending data to GLOBE right away and then go back later to teach about what you are testing (pH, temperature, etc), the importance of water, water pollution, the water cycle, etc.

Time commitment: You will need an hour or so in class each week in order to teach the water lessons as well as a set time each week to go to the Sampling Site for data collection. If you choose to go to the site with only a small number of students each week, make sure that the group members change each week so all of the students have a chance to participate.

Choosing a Hydrology Study Site

Study Site Set-up – Activity 1

<u>Note</u>: You, the teacher, should do this activity on your own before starting the Hydrology Program with the students.

Materials / Preparations:

- Paper and pencil

To Do:

Site Selection

1. Any larger body of water – seasonal or year-round – is acceptable for a study site. These can include rivers, streams, lakes, ponds, or other bodies of water.
   a. If you have a choice of water sources, the water bodies that scientists are most interested in are (in order of preference):
      i. Stream or river
      ii. Lake, reservoir, bay, or ocean
      iii. Pond
      iv. An irrigation ditch or other body of water used because one of the above is not accessible or available within your GLOBE Study Site.
2. The site should be close enough to your school so that students are able to take data at roughly the same time during the day, on a weekly basis.
3. If an appropriate site does not exist near your school, we encourage you to focus on the other GLOBE Protocols rather than try to force your way through a difficult situation.

Choosing a Sampling Site within the Hydrology Study Site

1. Once a body of water has been selected, the next step is to choose a place along its bank where weekly data will be collected. This will be your **<u>Sampling Site</u>**.
2. If the site is a moving body of water, like a stream or river, locate your Sampling Site at a riffle area (a place where the water is turbulent and moving, but not too fast) as opposed to still water or rapids.
3. If the site is a still body of water, like a lake or reservoir, choose a Sampling Site near the outlet area or along the middle of the water body, but avoid taking samples near an inlet. A Sampling Site located off of a bridge or a dock is also a good choice.
4. If the Study Site is located on a brackish or salty body of water and is affected by tides, you will need to know the high and low tide times at a location as close as possible to your Study Site.

Preparation for Documenting your Hydrology Study Site

1. Once you have selected a Hydrology Study Site, you will need to document it and send this information to GLOBE. While you will need to do some of this yourself, we suggest you involve the students as much as possible in the process. Thus, you will find a lesson entitled “Documenting Your Hydrology Study Site” following the introductory lesson of this section.

Introduction to the GLOBE Program

GLOBE Hydrology – Lesson 1

Materials / Preparations:

- Matches
- List of participating GLOBE countries *(below)*
- Map of the world or a globe *(if necessary, there is a small map following this lesson)*
- Students' GLOBE notebooks

Lesson Plan:

Introduction to GLOBE

1. Ask each student in the class to introduce himself to you and the rest by saying his or her name and an interesting fact about himself, for instance his favorite food.
2. Write the word "globe" on the board and ask the students "What is a globe?" Show them a globe if you have one.
3. Explain that GLOBE is also the name of our program.
4. Explain that GLOBE is an acronym that stands for "Global Learning and Observations to Benefit the Environment." Write this on the board.
5. Explain that the program started in 1996. Now it is in over 7500 schools in 110 countries. The students of these schools have become scientists and they do real research on the environment. In addition, they share their data with environmental scientists and other schools around the world via the internet.
   a. Definition: The **internet** is a system of communication that allows computers around the world to share information with each other. It is like a cell phone network but for computers.
6. The Nigerien government invited the GLOBE Program into the country in 2005 and it is now within the Ministry of Education and managed by the *Cellule Pour la Généralisation et Pérennisation de l'Éducation Environnementale (CGPE)*.

Goals of the GLOBE Program

1. The GLOBE Program has two linked objectives, **science** and **education**.
2. At out level, the program has the goal of helping you to:
   - Become good scientists
   - Better understand your environment
   - Understand the scientific method
   - Use scientific instruments
   - Take measurements
   - Use the internet to put your data at the disposition of students and scientists around the world, and
   - Create links between science, math, technology, and the environment.
3. GLOBE student scientists study 5 aspects of their environment:
   - Atmosphere
   - Hydrology
   - Soil
   - Land cover (vegetation)
   - Seasonal changes
4. We will start with Hydrology – the study of water. But first, let's play a game.

Game: Discovering GLOBE Countries around the World

1. Divide the class into teams. Tell each team to take out a blank sheet of paper.
2. Explain that GLOBE is in many countries on all of the continents.
3. Explain that the teacher will light a match and during the time that it burns, each team should try to write down as many country names as they can.
4. Once the match burns out, light another match and keep playing.
5. Once the second match goes out, take each team's list and circle the names of all the countries that host the GLOBE Program. Write these on the board as well. For each GLOBE country they guessed, the team that wrote it earns a point. Write the score on the board.
6. After you have written all the GLOBE countries named by the teams, add up the score and say which team won.
7. Leave the names of the GLOBE countries on the board and ask if any students have thought of any others, and write these on the board.
8. Show them the locations of each country that they named on a globe or on a map of the world. *(If needed, there is a small map below)*
9. ***Modification 1***: Each time that you play this game in class, show the students 5 or 6 GLOBE countries on a globe or map that they do not know. Then, in playing this game several times during the school year, the students will slowly learn many of the world's countries.
10. ***Modification 2***: Give each team a copy of the map below. Then, say the name of a country and each team attempts to place a finger on the country on their map. Give a point to each team that correctly responds and correct each team that does not.

Preparation for the Next Lesson

1. Ask the students to pose the following questions to their parents concerning your Study Site and to bring their responses back for the next lesson. In order to save time, divide the class into groups and give one or two questions to the members of each group. These questions should be recopied into their GLOBE notebooks:
    a. What was the river (lake, pond…) like when you were a child? Was it the same as it is today? What are the changes that you have seen regarding:
        - The quantity of water? Is it the same as before during the rainy season and the dry season?
        - The quality of the water? Is the water now more or less dirty and polluted than before?
    b. What living things were found in the river (lake, stream…) when you were a child?
        - Are they still there?
        - Are they there in the same quantities as before?
    c. In your opinion, what are the causes of the changes that you have seen?
    d. In your opinion, what will the river (lake, pond…) be like ten years from now?
    e. Is anyone working to improve or protect the water in our community? Why or why not?
    f. What is the importance of the river (lake, stream…) to humans and other animals? What are activities that take place at or depend on the river (lake, stream…)?

GLOBE Countries of the World

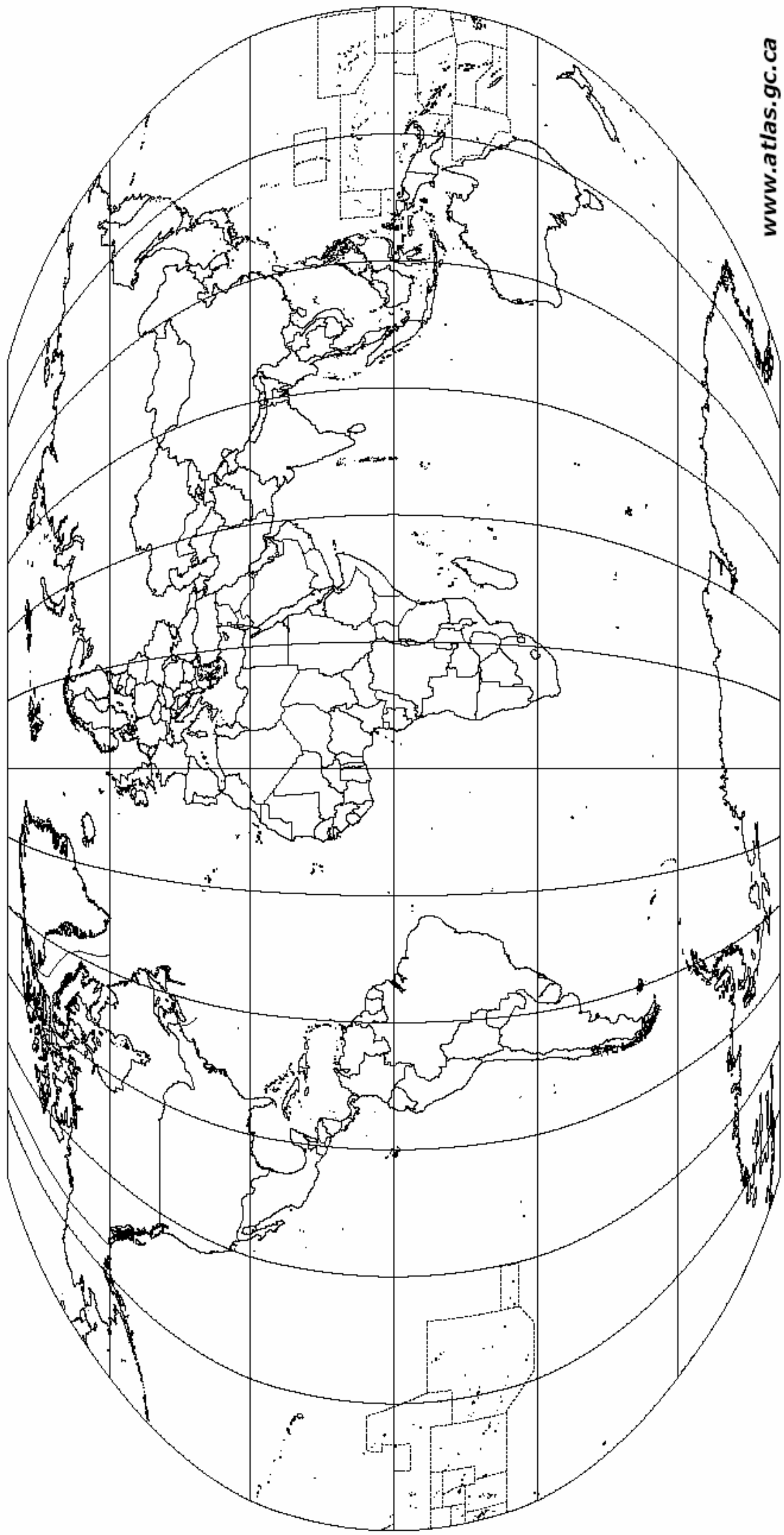
Argentina
Australia
Austria
Bahamas
Bahrain
Bangladesh
Belgium
Benin
Bolivia
Bulgaria
Burkina Faso
Cameroon
Canada
Cape Verde
Chad
Chile
Colombia
Congo
Costa Rica
Croatia
Cyprus
Czech Republic
Denmark
Dominican Republic
Ecuador
Egypt
El Salvador
Estonia

Ethiopia
Fiji
Finland
France
Gabon
Gambia
Germany
Ghana
Greece
Guatemala
Guinea
Honduras
Hungary
Iceland
India
Ireland
Israel
Italy
Japan
Jordan
Kazakhstan
Kenya
Korea, South
Kuwait
Kyrgyzstan
Latvia
Lebanon

Liechtenstein
Lithuania
Luxembourg
Macedonia
Madagascar
Maldives
Mali
Malta
Marshall Islands
Mauritania
Mexico
Micronesia
Moldova
Monaco
Mongolia
Morocco
Namibia
Nepal
Netherlands
New Zealand
Niger
Nigeria
Norway
Pakistan
Palau
Panama
Paraguay
Peru

Philippines
Poland
Portugal
Qatar
Romania
Russia
Rwanda
Saudi Arabia
Senegal
Serbia and Montenegro
South Africa
Spain
Sri Lanka
Suriname
Sweden
Switzerland
Tanzania
Thailand
Trinidad and Tobago
Tunisia
Turkey
Uganda
Ukraine
United Arab Emirates
United Kingdom
United States of America
Uruguay

THE WORLD / LE MONDE



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Introduction to Hydrology

GLOBE Hydrology – Lesson 2

Materials / Preparations:

- One 1-liter clear bottle filled with exactly 1 liter of water (color the water with some food coloring or another colorant like Jolly Jus)
- Five small jars
- Medicine dropper
- Some salt
- 100 mL and 500 mL graduated cylinders for measuring the quantities of water
- Students' GLOBE notebooks

* *Place all of the materials from the list above on the teacher's desk so all of the students can see them and follow along.*

Lesson Plan:

Discuss the Questionnaire

1. Take the time to go over the answers that the students collected from their parents and lead a discussion based on their responses.
2. Make sure that you ask each student to share at least one of the responses that they collected in order to acknowledge and appreciate the work that they did.
3. Sum up the answers of the students in a sentence or two for each question on the blackboard.
4. Ask the students to recopy the summary of what was discovered in their GLOBE notebooks.

Introduction to Water

1. Water is one of the most important things on earth and it is necessary for all life. Where there is no water, there can be no life.
2. A molecule of water (a single unit) is made up of two hydrogen atoms and one oxygen atom, so water is often written as its chemical formula, H_2O.
3. Water is one of the most abundant molecules that we see. However, the amount of water available to us is limited by two things: our location, and the purity of the water around us.
4. Ask the students, "Where is most of the water on Earth – in oceans, lakes, rivers, or icebergs, glaciers, or wells (groundwater)?"
    - The students should respond in oceans.
5. Tell them, "In fact, oceans cover almost 3/4 of the surface of the Earth." *(If you have a globe, you can show them.)*
6. "But, can humans drink the water from the ocean?"
    - No.

7. “Why not? “
    - It is too salty.
8. “Let’s do an activity that demonstrates just how much water there is on the Earth and how much of that is actually available for us to consume.”

*Water Percentages Activity**

1. Give the students the following background information:
    a. 97% of the earth’s water is too salty for human use.
    b. The remaining 3 percent is fresh water that we can use, but most of it is in polar icecaps, remote glaciers, and icebergs and is not easily accessible.
    c. Accessible fresh water, therefore, comes from **surface water** and **groundwater** sources. Surface water includes lakes, rivers, streams, etc. Groundwater is stored in layers of rock deep underground, and we can access it via wells. These sources represent **less than** **one percent** of all water on the earth.
2. Have the students copy the following table into their GLOBE notebooks. We will fill in the values for the second column in a moment.

Earth’s Total Water Supply	If all of the water on earth were equal to a liter of water, then each of these water supplies would be equal to the following amounts:
97.2% Oceans (salt water)	___________
2.38% Icecaps and glaciers	___________
0.39% Groundwater	___________
0.029 % Surface water (lakes, rivers, etc.)	___________
0.001 % Air and the surface of the soil	___________
=100% of the water on Earth	=_________

3. Tell them that we are going to see what these percentages mean proportionally. A **proportional representation** is a model that we look at to understand something that is either too big or too small for us to see it in its real size.
4. Show the students the 1 L of colored water in the bottle. Tell them that because we cannot get all of the water in the world into one room, we will use the liter of water to represent the earth’s entire supply of water. Tell them that one liter is equal to 1000 mL and ask them to try and remember the values as they go along.

5. Using the graduated cylinder, ask a student to measure out 28 mL of this water and pour it into a glass jar. Tell them that it represents the **fresh water** of the Earth. Set this aside for now.
6. Ask a student to pour a handful of salt into the remaining 972 mL of water in the bottle. Explain that this represents the salt water found primarily in oceans. Remind them that it is undrinkable because it is too salty.
7. Now, show them the 28 mL of water you had set aside. Explain again that this 28 mL of water represents the earth's total fresh water supply.
8. Then, have a student divide the 28 mL of fresh water with a graduated cylinder into the following volumes and place each amount into one of the four empty glass jars:
    a. Pour 23 mL into a jar and explain this represents icecaps (the large sheets of ice that are found at either pole of our planet), icebergs (frozen chunks of water floating in the oceans, and glaciers (moving sheets of ice that reside in the mountains of the world).
    b. Pour 4 mL into another jar and explain this represents groundwater (water that is stored deep in the ground).
    c. Suck up the remaining mL in the dropper and drop 2 drops into another jar, explaining that this represents all surface water, such as lakes, ponds, rivers, and streams.

       Note: 1 mL = 3 drops.

    d. Drop the final 1 drop into the last jar and say it represents the water in the atmosphere and soil (top layer of the ground).
9. Test your students' memory by asking them to help you fill in the table on the board and account for the 1000 mL of water that represents the Earth's water supply. Start with the first 972 mL that represent the world's salt water. See the answers in the table below.
10. Have the students copy the proportional values into their notebooks to complete their tables.

Earth's Total Water Supply	**If all of the water on earth were equal to a liter of water, then each of these water supplies would be equal to the following amounts:**
97.2% Oceans (salt water)	972 mL
2.38% Icecaps and glaciers	23 mL
0.39% Groundwater	4 mL
0.029 % Surface water (lakes, rivers, etc.)	2 drops (0.67 mL)
0.001 % Air and surface of the soil	1 drop (0.34 mL)
=100% of the water on Earth	=1 Liter (1000 mL)

Discuss the Results of the Demonstration

1. Ask the students to examine and compare the different volumes of water in the bottle and glass jars then ask the following questions:
    a. Where is most of earth's water found? (Oceans)
    b. Some cities are right next to the ocean, like Lomé, Accra, Conakry, Miami, and New York. Can they use the water from the oceans for households and industry? (No, the ocean water contains salts that are harmful to humans, plants, animals, and the metals of machines.)
    c. Do you think that the salts can be removed from ocean water? (Yes, but the desalination process is very expensive and uses a lot of energy.)
    d. Which of the four fresh water jars do you think represents the freshest water on earth? (23 mL, representing icecaps and glaciers)
    e. Are icecaps and glaciers a source of fresh water commonly used by humans for drinking, watering animals, cleaning, and so on? Explain why or why not. (No, icecaps and glaciers are found at the poles of the Earth or high in the mountains and are usually too far away from population centers to be useful. Plus, they would have to be melted first.)
    f. Approximately what percentage of the earth's fresh water is groundwater? (0.39%, or less than one-half of one percent)
    g. Why do you think the little bit of water in the atmosphere is important to plants, animals, and humans? (Water in the atmosphere can turn into rain, snow, sleet, and hail supply fresh water sources such as lakes, streams, and groundwater. Rain can help nourish crops.)
2. So, as you can see, the amount of water that is available to us is just a tiny portion of the water that is on the Earth's surface.
3. **We have to work to protect this water so we do not lose it as a resource.**
4. We are going to help scientists keep track of changes in the Earth's water by taking water data ourselves and sending it to them.

Extensions for Older Students

1. Have the students write down the percentages of water distribution on a sheet of paper from the table in their notebooks. Can they express these percentages in fractions (hundredths and thousandths)?
2. Have the students think of several ways that salt water could be distilled to make drinkable fresh water. (You might divide them into groups.) Allow them to sketch distillation devices to provide families or communities with large amounts of water.

Importance of Studying Water

1. Explain that scientists want data from our community to put with data from other communities around the world so they can:
    a. Keep track of how clean water sources are around the world;
    b. Monitor water health and identify polluted bodies of water and the sources of that pollution;
    c. Be able to head off water shortages for populations around the world by tracking changes in water levels and quality;
    d. Monitor the health of animals and plants that live in and depend on certain water sources around the world; and
    e. Having a global set of data to use when other questions, problems, and interesting things to study come to the attention of the scientific world.

2. Explain that for all these reasons, water is one of our most important resources and that if we do not study, understand, and protect this resource the quality of our lives will be significantly reduced or even impossible in certain areas.
    a. For example, there are certain rivers and lakes in China that are so full of toxins from the many factories on the banks that nothing can live in them anymore. People are unable to drink or use the water in any way and it would poison them if they did.

Optional Activity

1. Have the students sing the following song to the tune of "My Bonnie Lies Over the Ocean" or make up your own:**

The Earth is all covered with ocean.
The Earth is all covered with sea.
The Earth is all covered with ocean.
More water than land, don't you see?

Chorus
Water, water, there's water all over the world, the world
Water, water, there's water all over the world.

So salty and cold is the ocean.
So salty and cold is the sea.
So salty and cold is the ocean.
Too cold and too salty for me.

Repeat Chorus

Atlantic, Pacific, the Arctic,
And then there's the Indian too.
These oceans all over our planet.
I named them all, now can you?

Repeat chorus

La Terre est couverte par des océans
La Terre est couverte par les mares
La Terre est couverte par les océans
Plus de l'eau que la terre, tu vois?

Chorus
L'eau, L'eau, il y a l'eau sur tout le Monde, le Monde
L'eau, L'eau, il y a l'eau sur tout le Monde.

Très salés et frais sont les océans.
Très salés et frais sont les mares.
Très salés et frais sont les océans.
Trop salés et frais pour moi.

Répéter chorus

Atlantique, Pacifique, et l'Arctique
Et puis il y a l'Indien aussi
Ces océans couvrent notre planète
Je les ai nommé, peux-tu ?

Répéter chorus

* *Source Credit: The "Water Percentages Activity" is derived from the Water Sourcebook series of lessons from the U.S. Environmental Protection Agency (EPA).*

** *Source Credit: The Water Sourcebook, but originally appeared in Ranger Rick's NatureScope: Diving Into Oceans, National Wildlife Federation, Washington, DC, p. 8, 1989.*

Documenting your Hydrology Study Site

GLOBE Hydrology – Lesson 3

Materials / Preparations:

- A copy of the Hydrology Site Definition Sheet
- GPS receiver *
- GPS Protocol Field Guide *
- Digital or regular camera *
- Compass *

**If you lack these instruments, do the lesson without them until you can arrange a visit from a GLOBE Representative who can loan them to you.*

Go Out to the Hydrology Study Site

1. With either the whole class or a select group of students, go out to the Hydrology Study Site.
2. Have the students fill in the following data collection sheet based on their observations of the site.

Photographs of the Site

Note: If you don't have a camera, skip this part until you can arrange a visit from a GLOBE representative who can loan you one.)

Note: Use this opportunity to teach the students about how to use a camera. Involve the students as much as possible.

1. Standing where you will be collecting your water sample, take four photographs of your sampling area (if possible), one in each cardinal direction (N, S, E, W). Use a compass to determine the direction.
2. If using a film camera:
    a. Print two sets of photographs. You will keep one set for your records and the other will be mailed later to GLOBE.
    b. Label the back of each photo with your school's name, your Hydrology Study Site name, and the cardinal direction of the photo.
    c. In a letter, include your school name and address, your school's GLOBE ID (if you know it), the date and time you took the pictures (in Universal Time), the name of the water body, the name of the Study Site (for example, SWS-1), GPS coordinates of the site, the name of the GLOBE protocol (i.e. Hydrology), and any other information you think is important.

d. Mail a copy of the photos and letter to the following address:
   The GLOBE Program
   P.O. Box 3000
   Boulder, CO 80307-3000
   USA

   Note: GLOBE also asks that you draw a map of your site and send it along with the photos. We have included a site map-drawing activity as Lesson 7 with the students. Thus, you should wait to send in the photos until after Lesson 7 when you will have a completed map to send along as well.

3. If using a digital camera:
   a. Instead of mailing in copies of the photos, email a copy of each photo as an attachment to photos@globe.gov.
   b. In the body of the e-mail, include your school name and address, your school's GLOBE ID (if you know it), the date and time you took the pictures (in Universal Time), the name of the water body, the name of the Study Site (for example, SWS-1), GPS coordinates of the site, the name of the GLOBE protocol (i.e. Hydrology), and any other information you think is important.
   c. Go to the GLOBE website, www.globe.gov, and upload your data from the data sheet above by using your password and login.
   d. As noted above, GLOBE also asks that you draw and send a map of your site. This is included as Lesson 7 below.

Preparation for the Next Lesson

1. Explain to the students that during the next lesson we will practice collecting a water sample at our Sampling Site so we will have water to test.

Hydrology Site Definition Sheet

Basic Information

School Name: ________________________________

Class or Group Name: _________________________

Date: _______________________________________

Name(s) of Student(s) Filling in Site Definition Sheet: ___________________________

____

Information About Your Water Body

Name of Water Body: ____________________________

(Give the name listed on maps, if applicable)

Water Type: ❑ Salt (> 25 ppt) ❑ Brackish (2-25 ppt) ❑ Fresh (<2 ppt)

Is it Moving Water or Standing Water? ❑ Moving ❑ Standing

If Moving Water: ❑ Stream ❑ River ❑ Other: ____________________

Approximate Width of Moving Water: _________meters

If Standing Water: ❑ Pond ❑ Lake ❑ Reservoir ❑ Bay ❑ Ditch
❑ Ocean ❑ Estuary ❑ Other: ________________________________

Size of Standing Water:
- ❑ Much smaller than 50m x 100m
- ❑ Roughly 50m x 100m
- ❑ Much larger than 50m x 100m

Approximate Area of Standing Water: ____________km^2

Average Depth of Standing Water:_______________ meters

Location Where You Take Data: (Check one)
❑ Outlet ❑ Bank ❑ Bridge ❑ Boat ❑ Inlet ❑ Pier

Can You See the Bottom? ❑ Yes ❑ No

What Material(s) Do You See on the Bank? (Check all that apply):
❑ Soil ❑ Rock ❑ Concrete ❑ Vegetated bank

Bedrock (Check all that apply):
❑ Granite ❑ Volcanic ❑ Limestone ❑ Mixed ❑ Don't Know

Freshwater Habitats Present (Check all that apply):
❑ On rocks ❑ On/in mud ❑ On/in sand ❑ Vegetated banks
❑ Submersed vegetation ❑ Logs ❑ Don't Know

Saltwater Habitats Present (Check all that apply):
❑ Rocky shore habitat ❑ Sandy shore habitat ❑ Mud flats/Estuary ❑ Don't Know

General Description of the Site

Note: When you send your site definition data to GLOBE, the following items go under "General description of your study site and metadata (Comments)"

Types of plants observed in and around your body of water: ____________________
____

Types of animals observed in and around your body of water: __________________
____

Human uses of the water (for example, fishing, swimming, transporting goods or people, drinking water, irrigation, washing, etc.): ________________________________
____

Do you know of any upstream discharge into your body of water? _______________

Is the flow (streams) or water level (lakes) regulated or natural? (For example, flow is regulated downstream of dams.) ____

GPS Coordinates

Note: If you don't have a GPS unit, skip this part until you can arrange a visit from a GLOBE representative who can loan you one)

Note: Use this opportunity to teach the students about longitude, latitude, elevation, and how a GPS unit works. Involve the students as much as possible.

Latitude: _____________ ❑ N or ❑ S
Longitude: ____________ ❑ E or ❑ W
Elevation: _____________ meters
Source of Location Data (check one): ❑ GPS ❑ Other: ____________________

Additional Information for You (The Teacher) to Fill Out

Name of Site: ____

(Create a unique name that accurately identifies your site. If this is your first Hydrology Study Site, we suggest SWS-1. If it is your second site, use SWS-2, etc.)

Dissolved Oxygen Kit Manufacturer: ❑ Lamotte ❑ Hach ❑ Other: ___________
Model Name: ____________________________

Alkalinity Kit Manufacturer: ❑ Lamotte ❑ Hach ❑ Other: __________________
Model Name: ____________________________

Nitrate Kit Manufacturer: ❑ Lamotte ❑ Hach ❑ Other: _____________________
Method: ❑ Zinc ❑ Cadmium
Model Name: ____________________________

Salinity Titration Kit Manufacturer: ❑ Lamotte ❑ Hach ❑ Other: ____________
Model Name: ____________________________

Collecting a Water Sample in a Bucket

GLOBE Hydrology – Lesson 4

Materials / Preparations:

- Bucket with rope tied securely to handle (*For this first learning session, you may want to bring a few buckets and ropes so that several groups of students can all practice at the same time.)*
- Latex gloves *(Recommended to avoid getting your hands' salts and soaps in the water, but not necessary if precautions are taken to not touch the water sample itself nor the inside of the bucket)*
- *<u>Note</u>: This may also be a good point to teach the students at least one data collection protocol such as transparency or temperature so that they can start taking data right away, and then you can go back and teach the associated lesson later. If you choose this route, you will need the materials for that protocol.*

Lesson Plan:

Getting Ready

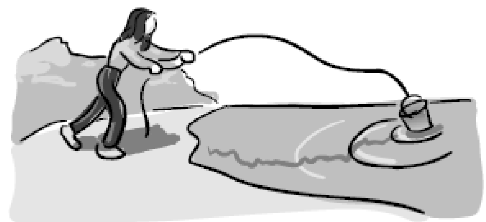
1. Explain to the students that in order to collect data from the water site, they will have to collect a water sample each time that they want to do a test.
2. Today, we are going to go out to our Sampling Site and learn how to collect a water sample.
3. Take the students out to the Sampling Site; demonstrate the appropriate water collection method following the steps below.
4. Then divide the class into groups and have the students practice the technique.

Sampling Steps

1. Rinse the bucket with sample water from the site. To avoid contamination, do not pour the rinse water back into the sampling area. Be careful not to disturb the sediment at the bottom of the water source. Do not use distilled water to rinse the bucket or use the bucket for any other purpose.
2. Hold tightly onto the rope. If your sampling site is a stream, throw the bucket out to a well-mixed area (a **<u>riffle</u>**), a little distance from the shore. Ideally, the water should be flowing at least slightly. If you are sampling from a lake, bay, or the ocean, stand on the shore and throw the bucket as far out as possible to collect your sample.

3. If the bucket floats, jostle the rope until some water enters the bucket. You should always take a sample from the top surface water. Be careful not to let the bucket sink to the bottom or stir up bottom sediment.
4. Allow the bucket to fill about 2/3 to 3/4 full and pull it back in with the rope.
5. Immediately begin testing procedures as the water has a shelf-life of ten minutes before a new sample must be drawn.

Rinsing the water bucket.



Casting the bucket.

Additional Protocols

1. If you have the time, teach a sampling protocol (transparency, temperature, etc.) before returning to class.
2. Take along a data sheet with you out to the Sampling Site and have students fill it in for your first data set as you are teaching them the protocol.

Preparation for the Next Lesson (2 options)

1. You, the teacher, have two options concerning which lesson to teach next:
    a. Option one: Teach students a few of the data collection protocols in order to start taking water data right away. We encourage you to take this route.
    b. Option two: Do not teach the testing protocols at this time and continue with the mapping lesson.

Teaching Additional Data Collection Protocols

GLOBE Hydrology – Lesson 5

Materials / Preparations:

- Protocol instruction sheets
- Data collection sheets
- Water sample collection bucket and rope
- Other materials that are necessary to carry out each protocol that you will be teaching

Note: Depending on how many protocols you will be doing, this lesson set may take one or more weeks to complete the teaching of all of the protocols. During these sessions, take all of the students along for training. Then, on a weekly basis, small teams of students can go and take data with you.

Lesson Plan:

Sampling

1. Explain to the students that today we will go to the Sampling Site and learn one or two new Data Collection Protocols as well as practice those that we learned last week.
2. Head out to the Sampling Site and teach one or two protocols as well as practice what was done the week before.
3. Return to class and store the data sheets in a safe place in order to send them onto GLOBE via the website.

Preparation for the Next Lesson *(If you have not yet mapped your site)*

1. Explain to the students that during the next lesson, they will practice drawing maps of a river in preparation for drawing a map of the Hydrology Study Site.
2. Students should come to the following class with a pencil, eraser, and notebook paper.

Practice Drawing a Map in the Classroom

GLOBE Hydrology – Lesson 6

Materials / Preparations:

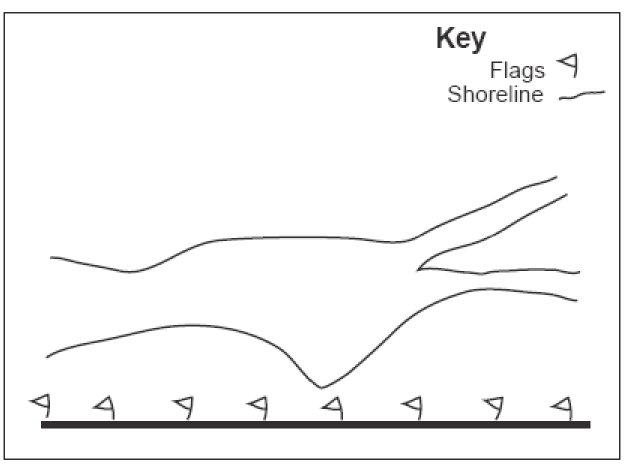
- Sheet of gridded notebook paper or "Bloc note" graph paper for each student
- Flags (11) or something else that can be used to indicate distance along the "bank" of the river, like material tied to sticks or old cans that have been brightly painted
- Measuring tape (50 m)
- Pencil/eraser for each student
- Students' GLOBE notebooks
- 10-15 random objects (such as cups, buckets, notebooks, branches, rocks, boxes, water bottles etc.)
- Compass, if available

Note: Before teaching this lesson, the teacher should read the entire lesson as well as the next lesson, "Outing to the Hydrology Study Site for Mapping." Be sure to see the examples that are presented so you are clear on what is expected regarding the level of detail of the maps and the type of information to include.

Lesson Plan:

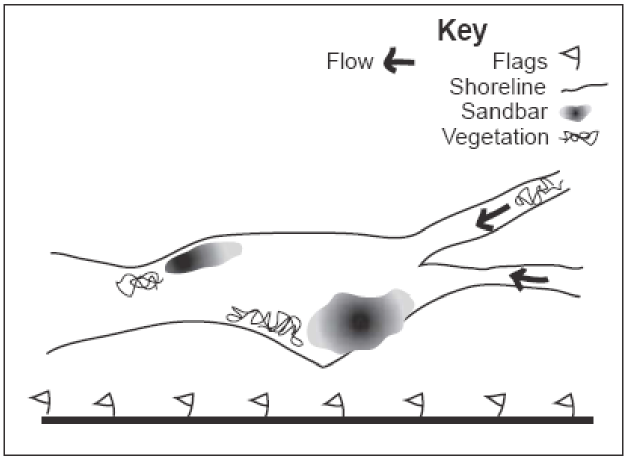
Mapping Examples and Expectations

1. You, the teacher should read the following example explanation of how to map the study site as preparation for teaching the students.
2. Example of How to Draw a Map of a Study Site

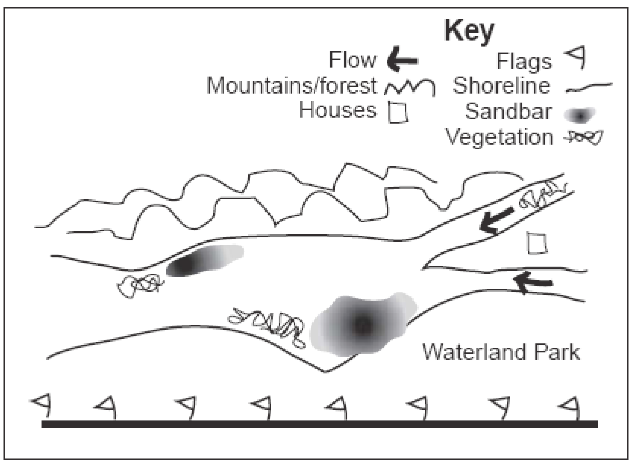


Begin by laying out a transect and marking it every 2 meters with flags. Each square on your paper will represent the area between two flags.

Draw the bank or coastline by measuring from the transect to the shore. If the far shore is too far away to fit on your map, indicate this with an arrow and the approximate distance.

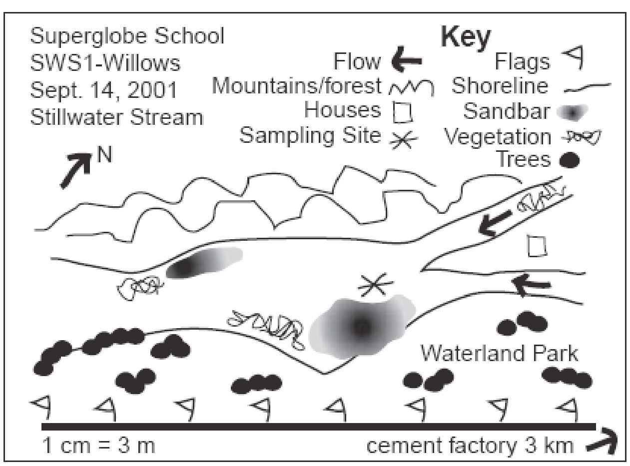


Add features from the surrounding area such as residential areas, trees, forests or grasslands, agricultural or recreational areas, parking lots, etc.



Add features to your water site. Show areas of different habitats, snags, dams or bridges, sand bars, etc. Use a different symbol in the Key to represent each feature.

Indicate the direction of water flow or inlet and outlets if known.



Add other features along the water site that might help identify your site or interpret your data such as cliffs, big trees, docks, limestone outcrops, clay deposits, etc.

Important features not shown on the map, such as industry or dams upstream, can be indicated with an arrow and approximate distance.

Add your school and site name, name of the water body, scale, north arrow, and date.

Preparation of the Students for Mapping

1. Explain to the students that they are going to practice drawing a map today in order to strengthen their powers of observation and to get ready to draw a map of the Hydrology Study Site.
2. Ask the students to arrange the desks around the sides of the classroom with the desks facing the center of the room. Use chalk to trace the banks and gentle bends of a river through the center of the classroom that is about 4 m long. Alternately, if it is not possible to rearrange the desks, go outside and use a stick to trace the banks and bends of a river in the dirt.
3. Explain that we are going to draw a map of this river by constructing a scale representation on our pieces of paper. We can then use the maps that we make to study and describe the river and its geographical characteristics to others.
4. Choose which side of the river will be the far bank and which side will be the close bank. (The far bank will go at the top of their maps and the close bank will go at the bottom of their maps.)
5. Take 10-15 random objects, such as buckets, branches, rocks, boxes, water bottles, etc., and place them in and along the bottom edge of the stream.
6. Explain to the students that the first step in drawing an accurate map is to measure the site and set out equally-spaced flags in order to match distances on the river with distances on their map.
7. Ask students to then lay out the measuring tape in a straight line along the edge of the close bank and to place a flag every 0.5m along the line.

Begin the Mapping

1. Now ask students to turn their paper so the long edges are the top and bottom of the page. Then have them draw the flags on the bottom edge of their piece of paper. If they are using gridded notebook paper, they should draw a flag at the end of every two squares, plus a flag at the very beginning (2 squares = 0.5m). This scale then: 2 squares = 0.5m, means that every 2 squares on your paper represents 0.5 m in reality. The scale is the link between the drawing in your notebook and reality. If they are using “Bloc note” graph paper, they should put a flag at the end of every four squares (4 squares = 0.5m).
2. Ask the students to write this scale on their maps.

   <u>Note</u>*: It would be a good idea to model this step on a sample map on the board so the students can clearly see what is going on. Keep the map on the board and use it to model the following steps as well.*

3. Now ask the students to draw the banks of the river onto their paper, using the following method:
   a. Measure the distance from the first flag directly to the “waterline”.
   b. Convert this measurement to the scale they are using for their maps.
   c. Place a dot on the map at the appropriate distance.
   d. When finished with all the dots, connect the dots with a dotted line to indicate the bank.
   e. Draw the opposite bank using the same method. *(When you are drawing the real map of your Study Site you may not be able to measure the far bank and will have to just estimate.)*

4. Using the same method as the first three steps above, draw in the objects in the river (buckets, etc.)
    a. Explain to the students that they do not have to draw a bucket, for example, for each time that there is a bucket. Instead, they can use a symbol, like a circle, to represent the bucket. Each time that they add a symbol to their map, they must also add it to a **key** (or **legend**) that accompanies their map explaining what each symbol represents.

    Note: Perhaps do one or two example objects on the map on the board so the students can clearly see what is expected of them. Pass through the class as students are working on their maps, encouraging them and helping them to line up the objects and flags on the ground and then to place those objects on the map. It would also be helpful to show them several legends on any commercial maps that your school may own.

5. If you have a compass, find which direction is North and have the students label North on their maps with an arrow.
6. Have the students label the maps with the "name" of the river that they have just drawn as well as their own names, and any other information that they think is important to add.
7. Have a few of the students present their completed maps to the class so their work can be appreciated by the other students.

Preparation for the Next Session

1. Explain to the students that they will be doing the same thing for a real site along the banks of a nearby body of water during the next session.
2. Have the students prepare a new piece of paper for a map, though this time use an entire double sheet of paper out of their notebooks (or a large sheet of graph paper, or two small sheets of graph paper taped together).
3. Starting at the lower left corner of the paper, have them draw a small flag on the line of each square across the bottom of the page for a total of 26 flags.
4. Have them write the scale on their maps. In our example, each 1 cm square will equal 2 m, but it may be necessary to make adjustments to this scale based on the grids actually found in your students' notebooks.

    Note: If you have larger sheets of paper available, you could ask the students to practice on that paper and use even a larger scale so they can make their maps more detailed.

5. Collect these maps for use next time, or instruct students to keep track of their own map and to bring it to the start of the next session.

Outing to the Hydrology Site for Mapping

GLOBE Hydrology – Lesson 7

Materials / Preparations:

- Students' sheets of gridded notebook paper with flags drawn in from the last lesson (1 flag every 1-cm square)
- Measuring tape (50 m)
- Pencil and eraser for each student
- Compass, if possible
- Students' GLOBE notebooks
- A hard surface such as a notebook for each student to use as a "desk" when at the site
- Flags (26) or something that can be used to indicate distance along the bank of the Study Site like material tied to sticks or old cans that have been brightly painted

Lesson Plan:

Preparation for Mapping

1. Ensure that each student has the necessary materials.
2. Briefly review with the students all the parts of the map that they are going to draw.
3. Explain what they will be mapping, including a list of objects or areas that might be included in their key as well as the symbols to use.

   <u>Note</u>: One approach to this would be to have the students copy a key from the blackboard of the symbols and words that they will be using during the mapping. This approach is contingent on the teacher going to the Hydrology Sampling Site ahead of time and creating a key based on his observations at the site for the students to then copy and use. DO NOT copy the key shown in the example for the students to use as it will not reflect your school's Sampling Site.

4. Explain that the best maps from the class will be sent on with your map to the GLOBE Scientists in the United States for their use.

Setting up the Study Site for Mapping

<u>Note</u>: The teacher can either do the following steps ahead of time, or with the students, whichever is easier or preferable.)

1. Go out to the Hydrology Study Site.
2. Select a part of your study site that is at least 50 meters long, if possible. The area should contain the sampling site where you collect your water measurements as well as a variety of habitats.

3. Use the measuring tape to measure a straight transect, at least 50 meters long, parallel to the shoreline, and within 10 meters of the bank. The transect will be varying distances from the water if the bank is not straight.
4. Place flags at the two ends and at every two meters along the transect.

Make the Maps

Note: Call out the instructions one by one for the creation of the maps. Encourage the students to walk up and down the bank as necessary in order to make their maps as accurate as possible. Pass among them and give your encouragements. Help them to see things that they have missed and ask them to include them in their maps.

1. Mark the transect and flag positions on the map.
2. Draw the waterline or bank by measuring from each flag directly to the water, converting it to the scale of the map, placing a small dot on the map at the appropriate distance, and then connecting the dots with a dotted line to indicate the bank.
3. Draw the opposite bank or indicate the approximate distance to the opposite bank if known.
4. Use an arrow to indicate the direction of water flow or the inlet and outlet of your water body.
5. Create a key with symbols for special features found at your site. Use these symbols to indicate where special features are located on the map. Suggested features include:
    - Within the sampling area: Riffle areas, pools, vegetated areas, logs, rocky areas, gravel bars, sand bars, bridges, docks, jetties, dams, etc.
    - Around the sampling area: Vegetation (or MUC codes – MUC identification books are available for loan from your GLOBE Representative), geological features such as cliffs or rocky outcrops, and man-made features such as houses, parks, parking lots, factories, roads, dumps or debris, etc.
6. Show the location of your Hydrology Sampling Site.
7. Include the following information on the map:
    - Name of site
    - Name of water body
    - North arrow
    - Date
    - Scale (ex. 1 cm = 2 m)
    - Key to all symbols used on the map

Return to Class

1. Return to the classroom and have the students share their finished maps. Have them vote on the best maps in the class. Collect all the maps for grading and set aside those that are to be sent on to GLOBE International.

Preparation for the Next Lesson

1. Explain to the students that during the next session we will start learning about the **water cycle**, the path that water takes as it travels around Niger and the world.
2. Ask the students to think about the path that water takes as it works its way around the world and to come with their ideas for the next session.

After Class

1. Photocopy your map and the best students' maps and keep the originals for your records.
2. Either on the back of a map or on a separate piece of paper, write your school's name and address, your school's GLOBE ID (if you know it), the date you drew the map, the name of the water body, the name of the Study Site (for example, SWS-1), GPS coordinates of the site, the name of the GLOBE protocol (i.e. Hydrology), and any other information you think is important.
3. Mail a copy of the maps and additional information to the following address:

   The GLOBE Program
   P.O. Box 3000
   Boulder, CO 80307-3000
   USA

4. Alternately, if you have access to an electronic scanner, you can scan a copy of the maps and e-mail them to GLOBE instead of sending them by regular mail. Include all the information requested above, and e-mail to photos@globe.gov.

The Water Cycle

GLOBE Hydrology – Lesson 8

Materials / Preparations:

- ❑ Water Cycle Image below (or another of your choice)
- ❑ Students' GLOBE notebooks

Lesson Plan:

Construction of the Water Cycle with the Students' Help

1. For this lesson, use the above water cycle description with or without modifications (or any other water cycle description that you have) according to the level of the students.
    a. Regardless of which water cycle description you use, be sure to emphasize the role that trees play in the creation of localized rain and cloud formation, as it is part of the cycle that is often overlooked.
2. Explain to the students that together we are going to create the Water Cycle on the blackboard and later they will copy it into their notebooks.
3. Explain that the cycle is important because it demonstrates how all of the water in the world is connected, from the pond outside during the rainy season to the Pacific Ocean near the United States.
4. Ask the students to share some of the ideas they came up with during their homework as to how the water cycles through our environment. Encourage the students through complimenting their answers.
5. Then, explain that we are going to now see the exact path that water takes through the whole water cycle.
6. Draw the water cycle on the blackboard, piece by piece, while at the same time following this series of questions:
    a. Draw an ocean (and/or a lake). Ask what will happen when the sun hits the surface of the ocean or any body of water. (Response: **evaporation** of some of the water.)
    b. Draw the water vapor leaving the ocean and ask students what will happen when the water vapor reaches a high altitude. (Response: the formation of clouds.)
    c. Draw some clouds and explain that some of the clouds will move from over the ocean (or lake) to the land. Ask what will happen to the water vapor contained in the clouds. (Response: it forms **precipitation** – rain, snow, etc.)
    d. What happens to the precipitation when it falls?
        i. 31% of precipitation runs over the surface of the earth and into rivers, streams, lakes, reservoirs, and ponds. This is called **runoff**. Some of this water will run all the way back to an ocean to restart the cycle!
        ii. Some of it gets stored in ice caps: Precipitation falls on top of huge pieces of ice at the Poles, called **ice caps**, and is stored there as ice.

            Note: Ice caps are huge pieces of ice by the North and South Pole that are at risk of melting because of Climate Change, also called Global Warming. If the polar ice caps melt, the level of the oceans will raise many meters and create problems the world over.

iii. Much of this precipitation is evaporated back into the air to form new clouds.
iv. Tell the students that some of this precipitation soaks into the soil and enters into another very important part of the water cycle:
  - Some of this precipitation soaks into the soil. This is called **infiltration**.
  - About 3% of water from rains soaks into the soil and passes to a great depth to become **groundwater**, held in large underground reservoirs.
v. Water is taken up from the soil and from underground reservoirs by plants and trees respectively.
  - This water is then evaporated from the plant's leaves, creating local water vapor. Evaporation of water from the leaves of plants is called **transpiration**.
  - If there are a lot of plants in a given area, especially a lot of trees, the evaporation is enough to produce local clouds and then rainfall.

e. Review: So, the water from precipitation goes to five places: runoff, ice caps, evaporation, transpiration, and infiltration.
  i. As it is often hard to tell the difference between the effects of evaporation and transpiration (what water vapor comes from what process), the two processes are often combined into one word, **evapotranspiration**.
  ii. About 66% of rainfall returns to the atmosphere through evapotranspiration from the surface of the earth.
    - Most of the rain in forests comes in this way. So, if people cut down all the trees in a region, they can lose much of the rain in that region at the same time.

7. At the end of the explanation, tell students to copy the water cycle into their notebooks. You could also ask them to explain their drawing to a partner once they are finished and waiting for the others.

Importance of Various Parts of the Water Cycle

1. Ask the students to identify places in the cycle where we are able to collect water for human use and consumption where we live. Have them indicate these places on their water cycle with a star. Their sites should include:
   - Rainwater (collection into cisterns or buckets)
   - Rivers and streams
   - Lakes and reservoirs
   - Underground water supplies (via pumps and wells)

   Note: Some students may want to label the ocean. Explain that the ocean is full of salt and in order to be able to be drinkable it must be processed in a factory and that it is a very expensive thing to do. So, while some countries in desert regions are starting to do that, sea water is not currently a viable source of water for most people.

2. Remind them that these sources represent a very small quantity of the total amount of water on the Earth and for that reason we need to understand the water cycle and work to preserve these water sources.

3. Ask the students to imagine what would happen to other parts of the cycle if one part were to stop working normally. For example, ask them to explain what would happen if the level of rain to a certain area were to decrease.
    - What would happen to the level of streams and rivers in the area?
    - What would happen to the level of groundwater and the wells that access them in the area?
    - What would happen to the plants and animals that depend on the rainfall and/or the rivers and lakes that the rains feed?
    - What would happen to farmers, herders, and other populations that are tied to the river?
4. Remind them that every step in the water cycle is important.
5. Remind them that since every step is important, we must protect streams, rivers, lakes, ponds, groundwater, and oceans from being polluted.

Supplementary Exercises in Groups or as Individuals:

1. Draw another cycle of your choice that is based on water. (For example: the life of a plant, the life of an animal, seasons, the level of a river or lake, the flowering of a tree, bird migration, etc.)
2. Share your cycle with the class.

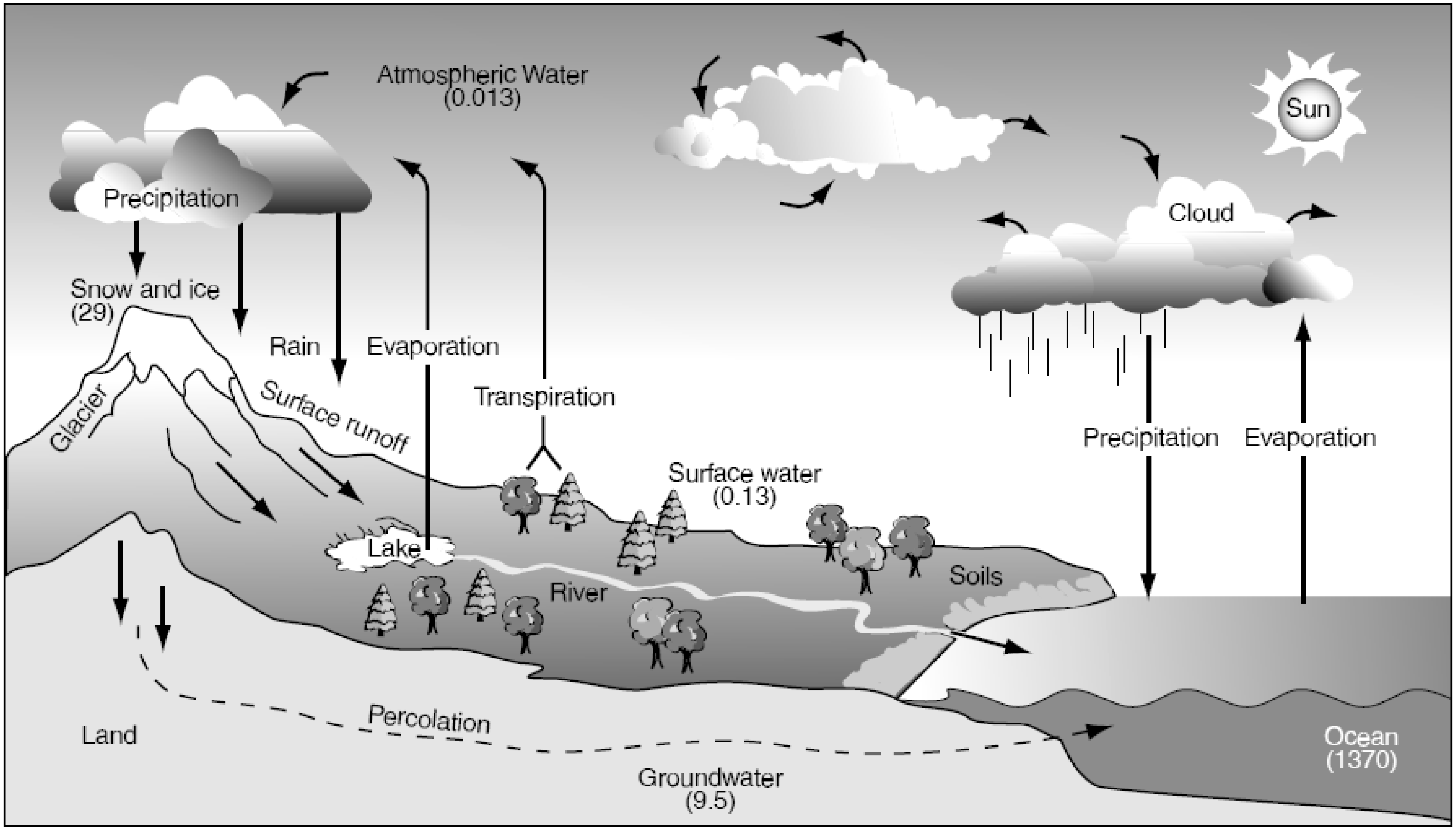
Preparation for the Next Lesson

1. Explain that during the next lesson we will examine how water flows over the surface of the Earth and how that water can become polluted even if you cannot see the source of the pollution.

Hydrologic Cycle

GLOBE Atmosphere – Water Cycle

Figure HY-I-1: Hydrologic Cycle - Numbers in parentheses are the reservoirs of available water in 10^3 Km^3.



After Mackenzie and Mackenzie 1995, and Graedel and Crutzen, 1993

Modeling a Watershed Basin

GLOBE Hydrology – Lesson 9

Materials / Preparations:

- Spray bottle or another method of sprinkling water on a plastic sheet
- Large plastic sheet (preferably clear or white) of at least one square meter
- Some objects to create "hills" *(ex. rocks, bucket, teapot; backpack, etc)*
- A few sprinkles of Jolly Jus or another water coloring agent to represent water pollution
- A small stone
- Sponges or pieces of cloth to model forests
- A bucket filled with water
- Cup
- Plastic classroom meter stick
- Students' GLOBE notebooks

Lesson Plan:

Introduction and Explanation of Gravity

1. Ask the students, "Where does the water in our river/lake/dam come from?" (From other countries, the rain, etc.)
2. Explain that we are going to make a model that shows where the water comes from.
3. Hold a ruler horizontally. Ask if you pour several drops of water on it, will the water run or will it stay in one place? Put the water on the ruler and show that the water doesn't move.
4. Hold the ruler at an angle and ask if you pour the same quantity of water on the ruler, will that water run or stay in the same place? Pour the water on the ruler and show that the water will run downhill.
5. Ask what makes the water run in the second example? Explain that it is the Earth's attraction to the water that makes it run downhill. This attraction is called **gravity**.

Prepare for the Experiment

1. Arrange some diverse objects like books, rocks, cups etc on a table or on the floor. Place the objects in such a way that when they are covered by the sheet of plastic, they will form a watershed basin. That is to say, if you pour some water anywhere on the plastic it will all eventually run to the same point at the edge of the plastic sheet.
2. Explain that this represents mountains and hills.
3. Show the students the spray bottle and explain that this will represent rain.
4. Say that now we are going do a small experiment with our model.

Problem and Hypothesis

1. Write the following problem on the board and ask the students to copy it in their notebooks: "**Problem**: What will happen when it rains on the hills? Where will the water go?"
2. Tell the students that **Writing the Problem** is the first step that all scientists do when they are conducting an experiment.

3. Tell the students that the second step that all scientists do when they want to do an experiment is to **Make a Hypothesis.**
   - Ask: What is a 'hypothesis?'
   - If they don't know, explain that it is a prediction of the results of the experiment.
   - Explain that all the good scientists in the world make a hypothesis before doing an experiment.
   - Explain that when you make a hypothesis, there is no right or wrong answer. It is only a guess.
4. Ask each student to write their own hypothesis to answer the problem. Have them write it in their notebooks under the title **Hypothesis**.

   Note: Remember, all responses are valuable and merit encouragement!

5. Choose five students to share their hypothesis with the class.
6. Explain that the third and fourth steps that scientists do during an experiment are to **Describe the Procedure** and **Do the Experiment**.

   Note: Since the procedure is simple in this case, we will jump straight to doing the experiment.

Do the Experiment, and Make Observations

1. Ask for a volunteer to play the role of a storm and, with the spray bottle, make it rain on the "hills".
2. Observe how the water runs downhill.
3. Explain that water always runs down a slope, towards the lowest place, because of gravity.
4. Explain that this is the same for all rivers and runoff: water runs down the hills and then downstream following the slope.
5. Explain the term "watershed": A **watershed** is an area of land in which all water that runs on its surface will eventually pass through a single river. A watershed can be very big or relatively small.
6. Explain that we are going to see how all the things that share a watershed are linked together.

Modeling a Polluted Watershed

1. Choose a spot on the watershed model where all of the water that is put on the model must cross. Tell the students to imagine that this is the location of the school. Place a stone here to mark the spot.
2. Put a little Jolly Jus or other coloring on one of the hills that is not in a direct line with the "school". Explain that this represents a source of pollution.
3. Ask the students, "The coloring could represent what type of pollution?"
   - The list of possibilities that they generate must include: a pile of trash, human feces, slaughterhouses, mechanics' shops, a place where soap is made, a place where animals come to drink and subsequently pee or defecate, a place where people wash their clothes, a mine, a dying shop, etc.
4. Ask if the people downstream can always see the pollution. (No.)

5. Ask each student to make a second hypothesis that responds to the following question: What will happen to the pollution when the rain falls on our watershed?
6. Ask several students to share their hypothesis with the class.
7. With the squirt bottle, make it rain on the "hills" and watch the pollution run down to the school.
8. Through questioning, help the students to arrive at the conclusion that the pollution above their village in the watershed, even if it comes from another village, will make its way to their sources of water.
9. Ask them to write a few observations in their notebooks concerning what they have seen in this trial.
10. Ask: How should this knowledge influence what we drink and what and how we throw things away?

Adding Trees to our Model

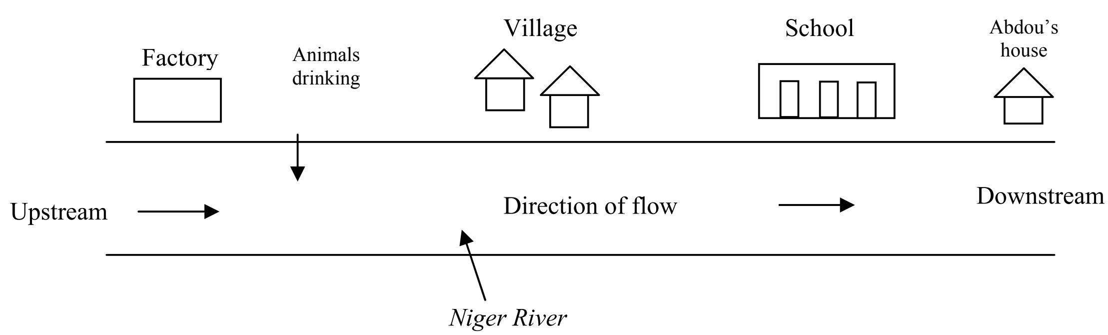
1. Wipe the colored water from the plastic.
2. Place some scraps of cloth or sponges on the hills of the watershed and explain that they represent forests and other vegetation.
3. This time, place some coloring in a place that will force it to run into one of these pieces of material or sponge.
4. Ask each student to make a third hypothesis at this time: What will happen to the pollution once the rains come to the watershed?
5. Ask some students to share their hypothesis with the class. *Do not criticize any hypothesis.*
6. Make it rain once again and observe what happens.
7. Ask: What happened to the pollution this time?
    - Response: It was stopped by the vegetation.
    - So, we can see that plants play a role in the filtration of our water.
    - But, they can't filter out all of the pollution, and they could also be killed by it.

Conclusion

1. Tell the students that the last step of an experiment is to **Write a Conclusion**.
2. Ask the students to write some sentences in their notebooks under the heading **Conclusion** about what happened during the experiment and if their hypothesis was supported or not supported.
3. Ask several students to read their conclusions to the whole class.

Verification of Comprehension

1. Draw the following image on the blackboard:



2. Tell the students to look at the drawing and list all of the things that affect the water in the river that flows past the school.
3. Ask the students to add other things that could affect the quality and quantity of the water but that are not on the drawing. Help them to create a good list.
4. Ask them to talk about the effects that their own activities might have on those that live downstream from them, like the family of Abdou.
5. Ask: What can you do to make sure that you do not ruin the water of others and to make sure that their waters are in good health?

Investigating Water Pollution

Globe Hydrology – Lesson 10

Materials / Preparations:

- Students' GLOBE notebooks
- Cup filled with clean water
- Lid to cover the cup

<u>Note</u>: *If you want to bring in some of the actual pollutants to make the demonstration more realistic, you are welcome to. These could include food scraps, laundry soap, fertilizer, dirt, motor oil, battery acid, and pesticide. In this case, you would also need a bucket of clean water to refill the cup as the demonstration progresses.*

Lesson Plan:

Biodegradable Wastes

1. Show the students the cup filled with clean water. Ask them if they would drink it. (Yes.)
2. Say: If I put in food scraps, would you drink it? (No.)
    - If I put in sewage from a latrine, would you drink it? (No.)
    - If I put in cow manure, would you drink it? (No.)
    - Why not? (It's dirty, it's polluted, it's unsafe to drink, it may make you sick, etc.)
3. The fish, the plants, and the other aquatic life don't like to drink it either as it can poison them.
4. All of these are types of <u>**Biodegradable Wastes**</u>. *(Write this on the board under the title "Types of Water Pollution," and write the other types as they come up below.)*
5. Another reason they are harmful is because bacteria like to eat them, and the more biodegradable wastes there are the more bacteria will grow. But bacteria consume the oxygen in the water, not leaving enough oxygen for the fish and other animals to breathe and causing them to die.

Plant Nutrients

1. Once again, show the students the filled with clean water. Say: Now I'm going to put some laundry soap into the water. Would you drink it? (No.)
2. I'm also going to put in some fertilizer. Would you drink it? (No.)
3. The fish, and the other aquatic life don't like to drink it either.
4. Things like soap and fertilizer contain nitrates and phosphates, which are types of <u>**Plant Nutrients**</u>. Plant nutrients are minerals that plants need in order to grow. Add Plant Nutrients to the growing list of pollutants on the board.
5. Why can plant nutrients sometimes be bad? They can cause certain plants like algae to grow and grow and grow out of control, killing the other living things in the water.

Sediments

1. Now I am going to put a big handful of dirt in the water. Would you drink it? (No.)
2. The fish, the plants, and the other aquatic life don't like to drink too much of it either.
3. Loose soil is called sediment. **Sediments** can get washed or blown into the water from the land nearby. Bare desert earth erodes very quickly, since there is no plant cover to protect soil from rainfall or wind. If too much sediment finds its way into a body of water, it can fill it up quite quickly.
4. Sediments are also bad because they can transport heavy metals or toxic chemicals into the water that can poison aquatic life.

Heat Pollution

1. Now I'm going to put this water on the fire until it is boiling. Would you drink it while it's boiling? (No.)
2. This is an example of **Heat Pollution**.
3. If the water is even a little bit hotter than the fish or other aquatic life are used to, they suffer or die. One reason is because hot water can drive oxygen out of the water, not leaving enough for the animals to breathe.
4. One source of heat pollution is electric power plants, which use nearby water sources to help cool down their machines. When they dump the heated water back into the water source they heat it up and harm plants and animals.

Hazardous and Toxic Chemicals

1. Now I'm going to put a bunch of nasty stuff in there. I'm going to put some motor oil, some battery acid, some pesticide, some dye from a material dying shop, and some medical waste from a hospital. Would you drink it? (No.)
2. Why not? (They are poisonous!)
3. They are poisonous for fish, plants, and other aquatic life too.
4. They are known as **Hazardous and Toxic Chemicals**.
5. Even a little tiny bit can be disastrous. A single quart of motor oil, for example, could pollute as much as 250,000 gallons of water. This is a major national and international health concern.
    a. Some hazardous and toxic chemicals come from very specific sources, like big factories, tanneries, or material dying shops. This is called **point source pollution**. It is very easy to identify the source.
    b. Other times pollution comes from many small sources across a wide area. For instance, if motor oil from 10,000 cars drips onto a paved road, and then it rains and the motor oil is washed away to a stream, it would be impossible to track down all 10,000 car owners. This is called **non-point source pollution**. It's not from just one specific place.

Radioactive Wastes

1. Now say that we are just downstream from a uranium mine and we take a cupful of water. Would you drink it? (No.)
2. Uranium mines are one source of **Radioactive Wastes**. Radioactive wastes accumulate (build up) in the body. Then, radiation from these wastes passes through the body constantly and can lead to cancer, other medical problems, and even death.
3. Children are more sensitive to the effects of radiation than adults.

Review

1. Read off each type of pollution from the now compete list on the board (biological wastes, etc.) and ask the students for examples of each type. Mix up the order to make it more of a challenge.

What Can Each of Us Do to Help to Prevent Water Pollution?

1. Ask the students for their ideas on what each of us can do to help prevent water pollution. Encourage their responses rather than condemning wrong answers by listing the good ideas on the blackboard.
2. After they have suggested some good ideas, add the following items:
    a. **<u>Be careful where you dump your wastewater! Don't dump any wastewater near a stream, river, lake, well, or storm drain.</u>**
    b. Urinate or defecate at least 30 meters away from a water source.
        - This helps prevent what type of pollution? (Biodegradable wastes.)
    c. Don't use more fertilizers than necessary. In many places, chemical tests indicate that individuals use 10 to 50 times more fertilizer than necessary for good plant health. Substituting compost as a mulch/fertilizer for gardens and landscaping can eliminate this potential pollution source.
        - This helps to prevent what type of pollution? (Plant nutrients.)
    d. Plant trees and fight against erosion and desertification.
        - This helps prevent what type of pollution? (Sediments.)

    <u>Note:</u> *Bare earth erodes quickly. So, if there is not any plant cover to protect the soil from wind or rain, it is impossible to avoid the arrival of lots of sediments in our waterways. Also, desert soils are naturally rich in salt, boron, and other oligo-elements, which are natural pollutants of water. Therefore, over-irrigation or erosion can wash these minerals into water sources and create pollution that can exterminate all the aquatic life in an area.*

    e. Virtually every liquid in an automobile is a serious pollutant, and care should be taken to avoid spilling oil, antifreeze, or other fluids from automobiles.
        - This helps to prevent what type of pollution? (Hazardous and toxic chemicals.)
    f. Use natural pesticides instead of chemicals.
        - This helps to prevent what type of pollution? (Hazardous and toxic chemicals.)
    g. Citizens can also become more politically involved. For example, encourage local government officials to enforce construction/sediment ordinances in your community. Encourage factories to reduce their wastes. Participate in public meetings to plan water policy. Organize litter clean-up campaigns and hold local fairs to educate your community about water resource issues.
3. Ask the students: From the list of actions on the blackboard, which of them can help to reduce water pollution? (All of these actions will reduce water pollution!)

Water Lessons and Technical Activities to Send Data to the GLOBE Program

<u>Note</u>: These protocols require equipment ranging from very cheap to somewhat expensive.

<u>Note</u>: You are welcome to teach the following lessons and protocols in whichever order you feel is best.

Water Temperature

GLOBE Hydrology – Lesson 11

Materials / Preparation:

- Meter stick or tape measure for estimation game *(optional)*
- Hydrology Investigation Data Sheet
- Calibrated alcohol-filled thermometer *(calibration instructions follow this protocol if necessary)*
- String and rubber band *(attached to the thermometer)*
- Clock or watch
- Latex gloves or clean plastic bags (to cover the hands in order to avoid contaminating the sample if you are later going to test pH or conductivity)

Lesson Plan:

Explanation (Review) of the Temperature Scale

1. Definition: **Temperature** is a relative measure of the quantity of heat in a body of matter.
2. You measure temperature with a thermometer in **degrees Celsius**.

Game: Estimating the Current Temperature

1. Ask each class group for an estimation of the current temperature and write each one on the blackboard. Ask several students to read the alcohol thermometer and see which group made the best estimation.
2. Explain the importance of being able to make accurate estimations.
3. If you have not already done so during another session, have the students make other estimations as a competition between groups. For example, have each group estimate the height of various classroom objects. Then, ask a student to measure each object and give a point to the team who is closest. Play several rounds. You could also have the students estimate the distance between objects in the classroom, students' heights…

Explanation of a Thermometer and How to Take Data from It

1. Start this session with the definitions of different types of thermometers so the students can distinguish between them.
2. Say: Remember that we use a thermometer to know the temperature of a body of matter. There are several different types of thermometers:
    - An **alcohol** or **mercury thermometer** is a sealed tube of glass that contains a liquid in a reservoir and has a scale printed on its side. When the temperature changes, the liquid in the tube contracts or expands, as does all matter, and it moves along the tube and the scale, thus indicating a change in temperature.
    - A **digital thermometer** uses a sensor and electronics to measure the temperature instead of the dilation of a liquid.

Optional Class-length Activity: Construction of a Thermometer

1. If you have not already done so, you might consider doing the "Construction of a Thermometer" activity found in the Atmosphere Program .

Why is Water Temperature Important?

1. Just as people can't live if the air temperature is to hot or too cold, aquatic animals and plants can't live if the water temperature is to hot or too cold.
2. The aquatic animals and plants are each adapted to a specific temperature range. Fish, for instance, that are adapted to a cold lake in Canada would not be able to live in a warm lake in Niger, and vice versa.
3. Bodies of water have different temperatures depending on latitude, altitude, season, time of day, depth of the water, and many other variables.
4. Sometimes temperature changes can be caused by humans. Some factories or power plants discharge water back into streams and lakes after they are done using it in their processes. If the water they discharge is a different temperature than the water already there, what can happen to the ecosystem of the river or lake?
    - Response: A change in temperature can kill off certain aquatic species. Plants and animals are adapted to certain ranges of temperature and if that changes, they can die.

How to Measure Water Temperature

1. Fill out the top portion of your Hydrology Investigation Data Sheet.
2. Put on the latex gloves or clean plastic bags. These are not necessary if you ensure that the hands do not touch the water in any way.
3. Slip the rubber band around your wrist so that the thermometer is not accidentally lost or dropped into the water.
4. Check the alcohol column on your thermometer to make sure there are no air bubbles trapped in the liquid. (If the liquid line is separated, there is an air bubble. To remove the bubble, hold the top of the thermometer and shake the thermometer by flicking the wrist in a downward motion several times. Be careful not to release the thermometer nor hit another object with the thermometer as you shake it.)
5. Collect a surface water sample in a bucket. See the instructions "Collecting a Water Sample in a Bucket."
6. Place the bulb end of the thermometer **in the center** of the sample water at a depth of 10 cm.
7. Leave the thermometer in the water for three minutes.
8. Read the temperature without removing the bulb of the thermometer from the water.
9. Let the thermometer stay in the water sample for one more minute.
10. Read the temperature again. If the temperature has not changed, go on to Step 10. If the temperature has changed since the last reading, repeat Steps 9 and 10 until the temperature stays the same.
11. Record the temperature on the Hydrology Investigation Data Sheet.
12. Have two other students repeat the measurement with new water samples.
13. Calculate the average of the three measurements.
14. All temperatures should be within 1.0° C of the average. If they are not, repeat the measurement.

Thermometer Calibration

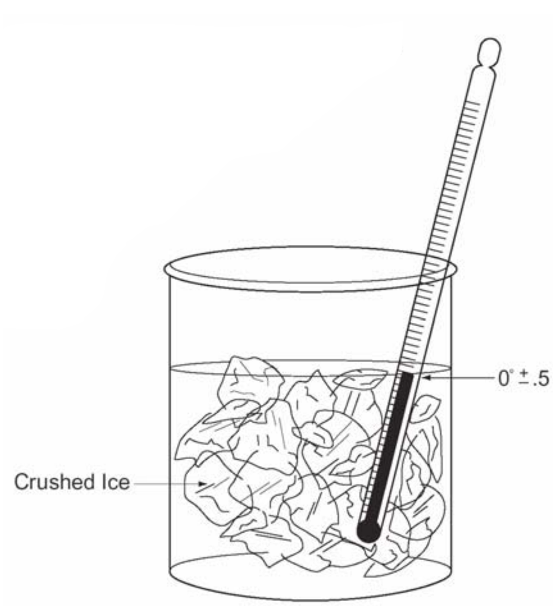
GLOBE Hydrology – Technical Document

Materials / Preparation:

- Calibration thermometer
- Crushed ice
- A clean container of at least 250 ml
- Water -- distilled is ideal, but the key is that the water is not salty *(in Niger, the square plastic bottles of distilled water made by CNES are best)*

To Do:

1. Prepare a mixture of fresh water and crushed ice with more ice than water in your container.
2. Put the calibration thermometer into the ice water bath. The bulb of the thermometer must be completely submerged in the water.
3. Allow the ice water bath and thermometer to sit for 10 to 15 minutes.
4. Gently move the thermometer around in the ice water bath so that it will be thoroughly cooled.
5. Read the thermometer. If it reads between -0.5° C and +0.5° C, the thermometer is calibrated.
6. If the thermometer reads greater than +0.5° C, check to make sure that there is more ice than water in your ice water bath. Fix the problem and repeat steps 3-5.
7. If the thermometer reads less than -0,5° C, check to make sure that there is no salt in your ice water bath. Dump out the mixture and repeat steps 1-5 with clean water.
8. If the thermometer still does not read between -0.5° C and +0.5° C, replace the thermometer. If you have used this thermometer for measurements report this to GLOBE.



Measuring Water Transparency

GLOBE Hydrology – Lesson 12

Materials / Preparation:

- Transparency tube (*see "How to Construct a Transparency Tube" below)*
- Cup for pouring water into the tube
- Latex gloves or clean plastic bags to cover your hands
- Hydrology Investigation Data Sheet
- "Collecting Your Water Sample in a Bucket" guide and materials (see *GLOBE Hydrology Program, Lesson 4)*

To Do:

Explain Water Transparency and Why It's Important

1. Definition: **Water transparency** is a measure of water clarity.
2. The clarity of the water determines how far down into a body of water light can penetrate.
3. If there are a lot of suspended particles in the water, the particles scatter light passing through the water and cause the water to become "cloudy" rather than clear. Suspended particles could include clays (through erosion of surface soils) or algae.
4. The transparency of water is important because it determines the depth to which aquatic plants can grow.
5. Light is essential for the growth of green plants. Sunlight provides the energy for photosynthesis, the process by which plants grow. Thus, the penetration of sunlight into a body of water determines the depth and quantity of underwater plants. Water transparency decreases as color, suspended sediments and algae increase. Most natural bodies of water have transparency ranging from 1 meter to a few meters. Extremely clear lakes and areas around clear coral reefs can have a transparency of up to 30 – 40 meters.
6. In this lesson, we are going to measure how deep the light goes in our body of water.

Sampling Procedure

1. Fill in the top portion of the Hydrology Investigation Data Sheet.
2. Record the cloud cover.

   Note: *There are more activities and explanations on cloud cover in the GLOBE Atmosphere Program in the Aerosols and Clouds section.*

3. Collect a surface water sample. See the instructions "Collecting Your Water Sample in a Bucket."

4. Stand with your back to the sun so that the transparency tube is shaded.
5. Use the cup to agitate the water in the bucket then take a sample of water out of the bucket using the cup. If you have not yet done the tests for pH and conductivity, do not dip the cup into the bucket, or remove the samples necessary for these tests first.
6. Pour sample water progressively into the tube using the cup. Look straight down into the tube with your eye close to the tube opening. Stop adding water as soon as you cannot see the pattern at the bottom of the tube.
7. Rotate the tube slowly as you look to make sure you cannot see any of the Secchi pattern through the water.
8. Record the depth of water in the tube on your Hydrology Investigation Data Sheet to the nearest cm.

   <u>Note</u>*: If you can still see the disk on the bottom of the tube after the tube is filled, record the depth as >120 cm.)*

9. Pour the water from the tube back into the sample bucket and mix up the remaining sample.
10. Repeat the measurement two more times with different observers using the same bucket of collected water.

How to Construct a Transparency Tube

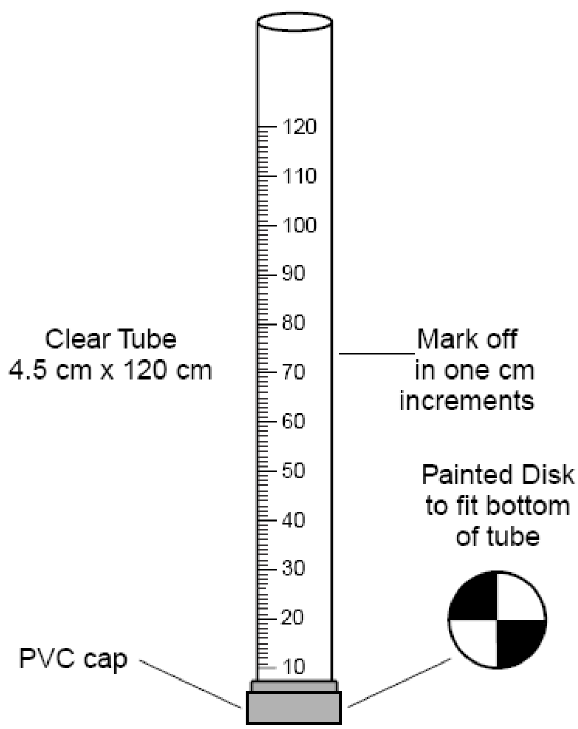
GLOBE Hydrology – Technical Document

Materials / Preparation:

- Clear tube (approximately 4,5 cm x 120 cm)
- Permanent, waterproof black marker
- PVC cap (to fit snugly over one end of tube)
- Meter stick

To Do:

1. On the bottom of the inside of the PVC cap, draw a Secchi disk pattern (alternating black and white quadrants) with the black marker.
2. Use the marker and meter stick to draw a scale on the side of the tube starting with 0 cm at its edge and going up to at least 120 cm. Once the cap is attached to the tube, the edge of the tube (0 cm) should line up with the Secchi disk pattern that is drawn on the inside of the cap.
3. Glue the PVC cap over the end of the tube where the scale starts (0 cm). The cap should fit tightly so water cannot leak out.



Measuring Electrical Conductivity

GLOBE Hydrology – Lesson 13

Materials / Preparation:

- Calibrated electrical conductivity meter

  Note: This meter must be calibrated before each use. Calibration instructions are below.

- A thermometer
- Two 100-mL beakers or small cups reserved for this task (to avoid contamination by soap or other chemicals)
- Hydrology Investigation Data Sheet
- Soft clean cloth or toilet paper
- Latex gloves or clean plastic bags to cover your hands
- One clean plastic water bottle with cap (for sample water)
- Distilled water in wash bottle

  ***Note**: In Niger, the round bottles labeled distilled water from Côte d'Ivoire are not distilled water and are less pure than the tap water here. Also, the battery shops in Niamey claiming to have distilled water actually only have filtered water from the Caterpillar machine shop. The only true distilled water that we have identified in Niger is the locally made distilled water from CNES (20.72.39.23) in the square plastic bottles. The Total gas stations around town usually carry CNES distilled water but the OiLibya stations do not.*

To Do:

Explaining Electrical Conductivity to the Students

1. The **conductivity** of a water sample is the measure of its ability to carry an electric current. We measure conductivity with a **conductivity meter**.
2. We measure the electrical conductivity to find out the amount of dissolved solids (called salts and minerals) in the water. The greater the electrical conductivity, the more dissolved solids (salts and minerals) there are in the water.
3. Fresh water has many natural impurities like salt or minerals. We can't see or smell them. As water comes in contacts with rocks and soil, minerals from the rocks or soil get dissolved into the water. Some companies sell mineral water in bottles to people who are interested in consuming the minerals that are dissolved in that water.
4. Fresh water also has many human-caused impurities that come from wastewater or run-off. Again, you can't always see or smell them. Just because a water body looks clean doesn't mean that it is!
5. Scientists want data on dissolved solids to determine its suitability for drinking, agriculture, or industry, and also in order to monitor if the water quality is getting better or getting worse.

Further Explanation for Advanced Students

1. Pure water has a very low conductivity because there are no impurities. In other words, pure water can't "carry" electricity through it very easily.
2. When certain solids like salts or minerals are dissolved in water, they form ions. Ions carry either a positive (+) or negative (-) charge that can then conduct electricity.
3. Therefore, the more ions in the water, the better it will conduct electricity.

Sampling Instructions

1. Calibrate the Electrical Conductivity Meter according to the calibration instructions in the Technical Document below, and using the temperature vs. conductivity table for your standard solution.
2. Go out to the Sampling Site.
3. Fill out the top portion of the Hydrology Investigation Data Sheet
4. Put the latex gloves or the clean plastic bags.
5. Collect a sample of water in a bucket according to the instructions in GLOBE Hydrology Program Lesson 4, above.
6. Record the temperature of the water to be tested. If water is between 20-30° C, go to step 5.
7. If your water is below 20° C or above 30° C, fill a clean plastic sample bottle with the water to be tested. Cap and bring back to the classroom. Allow the water to reach 20°-30° C, record the temperature and then proceed to step 5.
8. Rinse the two 100-mL beakers or clean cups two times with sample water.
9. Pour about 50 mL of water to be tested into each of the two 100-mL beakers.

   Note: As a reference if you do not have a graduated cylinder, 50 mL is about 5/7th of a small tomato paste can.

10. Remove the cap from the meter. Press the On/Off button to turn it on.
11. Rinse the electrode with distilled water. Blot it dry. Do not rub or stroke the electrode while drying it.
12. Put the electrode in the water sample in the first beaker. Stir gently for a few seconds. Do not let the meter rest on the bottom of the beaker or touch the sides.
13. Take the meter out of the first beaker. Shake gently to remove excess water, and then put it into the second beaker without rinsing with distilled water.
14. Leave the electrodes submerged for at least one minute. When the numbers stop changing, record the value on the Hydrology Investigation Data Sheet by Observer 1.
15. Have two other students repeat the measurement using fresh beakers of water each time. The meter does not need to be calibrated for each student. Record these measurements as Observers 2 and 3.
16. Calculate the average of the three observations.
17. Each of the observations should be within 40 µS/cm of the average. If one or more of the values is not within 40 µS/cm, pour a fresh sample and repeat the measurements and calculate a new average. If all observations still are not within 40.0 of the average, discuss possible problems with your teacher.
18. Rinse the electrode with distilled water, blot dry, and put the cap on the meter. Rinse and dry the beakers and sample bottle.

Comparing the Data to Some of the Uses of Water

1. The best water for household and drinking uses has a conductivity below 1100 μS/cm.
2. For agriculture uses, water should ideally have a conductivity around 2200-2600 μS/cm. Above these levels, damage to sensitive crops may occur.
3. How does the water at your study site fit with these uses of water?

Electrical Conductivity Calibration

GLOBE Hydrology – Technical Document

Materials / Preparation:

- ❑ Electrical conductivity tester
- ❑ Soft clean cloth or toilet paper
- ❑ Standard solution
- ❑ Two 100-mL beakers or two plastic cups
- ❑ Thermometer
- ❑ Latex gloves
- ❑ Distilled water in wash bottle
- ❑ Small screwdriver

Standard Solution

1. Standard solution is a solution with a known conductivity that is used to calibrate an electrical conductivity meter. Standard solution must be stored in a sealed container so that its conductivity is not changed by the evaporation of the solution. Also, it is preferable to store the standard solution in a refrigerator if possible.
2. Standard solution must be bought new from a scientific supplier from time to time (perhaps once each year) to ensure that the calibration value does not change.

Calibration of the Conductivity Meter

1. Take the temperature of your standard solution without contaminating the solution and use the temperature vs. conductivity chart for your standard solution to identify your solution's current conductivity. If the solution is stored in a refrigerator, the temperature of the fridge should equal the temperature of the solution. The same should be true for a solution stored with a thermometer taped to it in a shaded place.
2. Pour standard solution into each of the two clean 100-mL beakers or cups to a depth of about 2 cm.
3. Remove the cap from the electrical conductivity tester and press the On/Off button to turn it on.
4. Rinse the electrode at the bottom of the tester with distilled water in the wash bottle.
5. Gently blot dry with a cloth or tissue. Do not rub or stroke the electrode while drying.
6. Put the probe of the meter into the first beaker of standard. Stir gently for 2 seconds to rinse off any distilled water.
7. Take the meter out of the first beaker. Do NOT rinse it with distilled water and place it into the solution in the second beaker.
8. Stir the solution gently with the conductivity meter for a few seconds and then wait for the numbers to stop changing.
9. If the display does not read the value of your standard solution, you must adjust the instrument to read this number. For most meters, this is done by using a small screwdriver to adjust the calibration screw on the meter until the display reads the standard value.
10. Rinse the electrode with distilled water and blot it dry. Turn off the meter and put the cap on to protect the electrode.
11. Pour the standard from the beakers into a waste container. **Do not** return this standard solution to the original container. Rinse and dry the beakers.

Teaching about pH

GLOBE Hydrology – Lesson 14

Materials / Preparation:

- Choose 5-7 of the following solutions, making sure to get a good variety of acids and bases. Bring a couple spoonfuls of each solution in separate glass jars with lids to class. When making the solutions, try to be uniform in the quantities of water and product mixed together in every case. Be sure to label each container with the solution that it contains but do not note if it is an acid or a base.

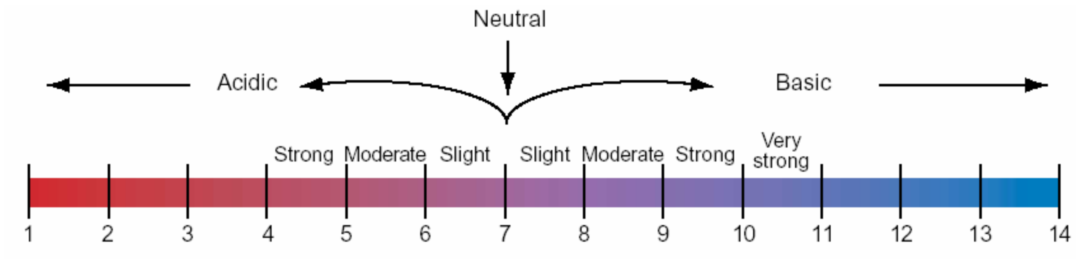
  Note: Be careful with the chemicals around the students in order to avoid chemical burns.

  - Lemon juice *(acid)*
  - Lemon juice diluted with water *(acid)*
  - Vinegar *(acid)*
  - Coffee/Nescafe *(acid)*
  - Orange juice *(acid)*
  - Battery acid *(acid)*
  - Well or pump water *(more or less neutral depending on the sample)*
  - Distilled water *(neutral)*
  - Milk *(base)*
  - Salt dissolved in water *(base)*
  - Shampoo or soap diluted in water *(base)*
  - Detergent dissolved in water *(base)*
  - Baking soda dissolved in water *(base)*
  - Bleach *(base)*
- pH paper or pH meter
- Plastic tweezers (for the manipulation of the pH paper)

Lesson Plan:

Explaining pH to the Students

1. Explain that all liquids are acidic, basic, or neutral. Pure water is neutral.
2. Give the students the following definition of pH: **pH** is a measurement that allows us to say whether a liquid is acidic, basic, or neutral.
3. The pH Scale ranges from 1 to 14 on a number line. Therefore, 7 (the pH of pure water) is in the center and is considered neutral. pH readings between 1 and 7 are called **acidic** with 1 being the strongest acid. pH concentrations between 7 and 14 are **basic** with 14 being the strongest base.
4. Draw the following number line on the board to help the students understand the idea of the pH scale:



5. Acids and bases have many varied and different uses. For example, many bases are used as solvents or in soaps for cleaning. Acids in our stomachs break up the food that we eat so we can absorb all of the nutrients out of the food and into our bodies.
6. If you have an upset stomach or heartburn, a glass of milk can help calm it. This is because milk is a base and it **neutralizes** (cancels out) the acids in your stomach to stop the burning.
7. So, it is important for us to know if a liquid is acidic or basic because this can help us know how to use it. We measure pH using pH paper or a pH meter.
   a. **pH paper** is chemically treated paper that undergoes a chemical reaction when it comes into contact with an acid or base. This reaction changes the color of the paper. By matching up the color change of the paper with a scale, we are able to know the pH of a liquid.
   b. A **pH meter** is a piece of electronic equipment that has two probes. When these two probes are placed into a liquid, they are able to measure the pH using electricity and then display the pH on a screen so we can read it.

Activity: Construct a pH Scale

1. Using one of the solutions that you have prepared and brought to class, demonstrate how to test its pH using either pH paper or a pH meter:

   Instructions for using pH paper:
   - Using tweezers, pull out and cut off a small piece of pH paper (1-2 cm) from the roll.
   - If you do need to use your hands for manipulating the paper a bit, don't touch the end of the paper that will go into the solution, as the oils from your hands will contaminate it and give you an inaccurate reading.
   - Using tweezers, quickly dip the pH paper into the solution. The pH paper will react almost instantly, so there is no need to leave the paper in the solution for a long time.
   - Gently shake any excess liquid off of the paper so you can get a clear color reading. Do not wipe off the pH paper or touch it to the side of the container!
   - Match the color of the paper to the scale on the pH paper dispenser and record the pH.
   - Throw away the used paper then rinse the tweezers with distilled or filtered water before drying them off. Then, repeat these steps for a new sample.

   Instructions for using a pH meter:
   - Follow the instructions found later in this guide under the title *Measuring pH using a pH Meter* along with the manufacturer's instructions for your particular pH meter.

2. Divide the class into groups and give each group a solution to test. Tell each group the contents of their solution but do not tell them if it is acidic or basic.
3. Construct a table on the blackboard, with a column for the selected **chemicals**, one for the **hypothesis of the pH**, and a third for the **pH results**. Then, ask each group come up with a hypothesis (a prediction or estimate) of what pH their solution will be and write their hypotheses up on the blackboard.
4. Draw a horizontal pH scale on the board, numbering the line from 1 to 14. Using an arrow and a label place the pH of the example solution on the scale.
5. Then, help each group to test their solution. Supervise the students, but make sure that they are doing the work themselves.
6. As each group tests their solution, have them go up and place their results on the pH scale and in the pH results column of the table. Also, have them compare their result to their hypothesis and discuss their accuracy with them.
7. Have the students copy down the scale and solutions from the board into their notebooks. You could also add a few other liquids and their pHs as needed from the image at the end of this lesson.

For Advanced Students: Explain a Logarithmic Scale

1. Each number on the pH scale represents a concentration that is **10 times** larger than the previous one. Any scale that is set up by powers of 10 is called a **logarithmic** scale.
2. In order to better understand this scale, we will continue to think of 7 as being the center of the scale as we look at a few examples: a 9 is ten times more basic than an 8; a 4 is ten times more acidic than a 5.
3. As the strength of one pH unit on the scale (between two numbers) increases 10 times, the strength of two pH units is one hundred times because 10x times 10x is 100x. For example a solution with a pH of 10 is one hundred times more basic than a liquid with a pH of 8 and a liquid with a pH of 3 is one hundred times less acidic than a pH of 1.
4. So, careful measurement is important, because a mistake of 1 pH unit means the pH is recorded as being 10 times off the mark.

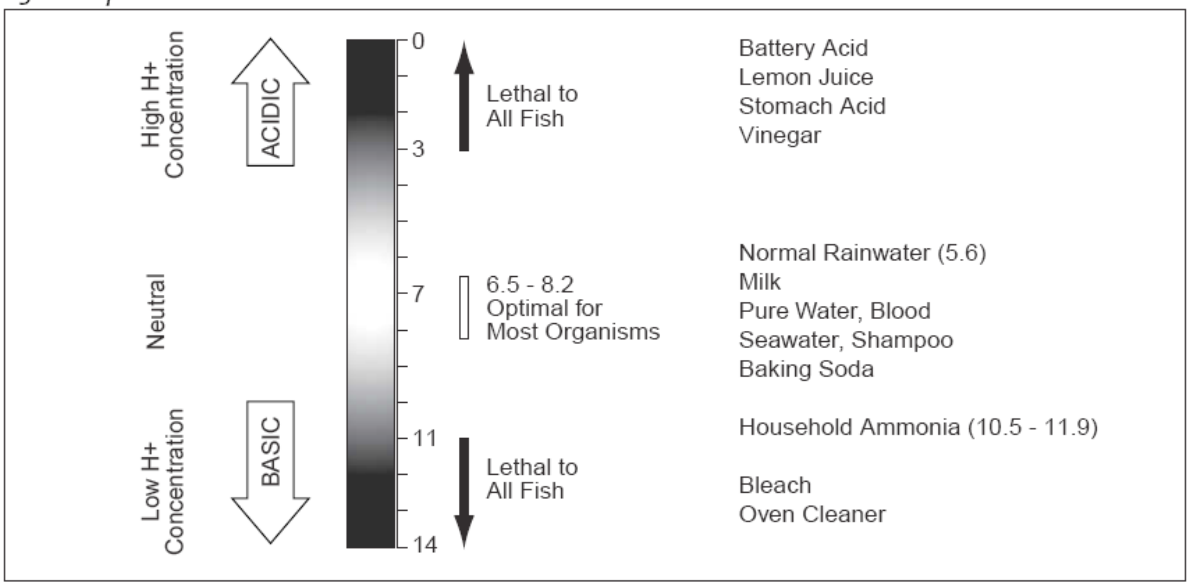
Why is Water pH Important for the Environment?

1. Water circulates through and moves in and out of every living thing. So, chemicals in the water can affect the lives and environments of these living things as the chemicals move with the water.
2. These chemicals come from many places such as:
   a. Toxic gasses in the air dissolve into raindrops that then fall into our water sources. Often, these chemicals come from human activities such as burning trash, driving cars…
   b. Waste liquids that come from factories or other human activities (like the soapy water from washing a bike or car) can drain into water supplies or other bodies of water, thus contaminating them.
   c. Chemicals can be leached out of the soil as they are irrigated for agricultural use and then move into bodies of water or water supplies.
3. Polluted water is very bad for the environment and living things:
   a. It weakens plants and makes them more susceptible to disease and insects that can kill them.
   b. It eliminates elements from the soil that are essential to plant growth.
   c. It releases elements into the soil that are poisonous to plants and to the animals that eat those plants.

d. It kills many aquatic animals such as fish.
e. If it gets into the water and food sources that humans use it can kill them, cause developmental problems in their children, or make certain areas uninhabitable by eliminating all sources of clean drinking water.

4. If one wants to stop water pollution, one needs to know its sources, the changes in its concentration, and its effects on the environment. GLOBE pH measurements will help scientists and governments to fight against this problem.
5. The following pH scale shows some products and their pHs in addition to the pHs that kill fish. If the pH of a body of water is less than 3 or greater than 11 all of the fish in the water will have died off.

Figure HY-pH-1



Measuring pH Using pH Paper

GLOBE Hydrology – Lesson 15a

<u>Note</u>: You can choose whether to use pH paper or a pH meter. The GLOBE Program accepts results from either.

<u>Note</u>: If you have a conductivity meter and know that the Electrical Conductivity of your water is greater than 200 µS/cm, you can skip the placement of salt into your testing sample. If need be, instructions for testing without the addition of salt are available through your GLOBE representative or at www.globe.gov under Hydrology Protocols.

Materials / Preparation:

- Hydrology Investigation Data Sheet
- Soft clean cloth or toilet paper
- Electrical conductivity meter *(optional)*
- Plastic tweezers
- pH paper
- Salt crystals (2 mm in diameter) or table salt
- Stirring rod or spoon
- A 100-mL beaker or small cup

Prepare the Sample

1. Fill in the top part of your Hydrology Investigation Data Sheet. In the pH section of the sheet, check the box next to 'pH paper'.
2. Put on latex gloves or clean plastic bags in order to prevent the oils on your skin from contaminating the water sample and changing the pH.
3. Rinse tweezers and the stirring rod or spoon with some of the sample water and dry with a clean cloth or toilet paper.
4. Rinse the beaker or cup with some of the sample water three times.
5. Fill one beaker or cup with about 50 mL of sample water. (A small can of tomato paste is around 70 mL, so about 5/7 of a tomato paste can is a rough indication of 50 mL.)
6. Using the tweezers, place one crystal of salt in the sample water. Do not touch the salt with your fingers as the oils and acids from your hands will change the pH of the water sample.

   If you do not have salt crystals, fill this letter O *(Times New Roman 20pt)* with a single layer of table salt and pour that into the sample water.

   <u>Note</u>: The salt helps the pH paper accurately measure the pH as the pH paper does not work very well if the conductivity of the solution being tested is less than 200µS/cm.

7. Stir thoroughly with stirring rod or spoon until the salt is completely dissolved.

Test for Conductivity (optional)

1. If you have an electrical conductivity meter, measure the electrical conductivity of the treated sample water using the electrical conductivity protocol, *Measuring Electrical Conductivity.*
   - If the electrical conductivity is 200 µS/cm or higher, record the value on Data Sheet.
   - If the electrical conductivity is still less than 200 µS/cm, go back to step 6 above and repeat until you get a value that is at least 200 µS/cm before continuing.

Test with pH Paper

1. Follow the instructions that come with your pH paper for testing the pH of the sample. If your pH paper does not have instructions, here are the instructions for most brands of pH paper with a testing range of about 1-13:

   Instructions for using pH paper

   a. Put on latex gloves or clean plastic bags over your hands.
   b. Using tweezers, pull out and cut off a small piece of pH paper (1-2 cm) from the roll.

   Note: If you do need to use your hands for manipulating the paper, don't touch the end of the paper that will go into the solution, as the oils from your hands will contaminate it and give you an inaccurate reading.

   c. Using tweezers, dip the pH paper into the solution. The pH paper will react quickly, so there is no need to leave the paper in the solution for a long time.
   d. Gently shake any excess liquid off of the paper so you can get a clear color reading. Do not wipe off the pH paper or touch it to the side of the container!
   e. Match the color of the paper to the scale on the pH paper dispenser and record the pH.
   f. Throw away the used paper then rinse the tweezers with some sample water before drying them off. Then, repeat these steps for a new sample.

2. Record your pH on the Data Sheet as Observer 1.
3. Repeat steps 3-9 two more times using new water samples and new pieces of pH paper. Record the data on the Data Sheet as Observer 2 and Observer 3.
4. Find the average of the three observations.
5. Check to make sure that each observation is within 1.0 pH units of the average. If they are not within 1.0 units of the average, repeat the measurements. If your measurements are still not within 1.0 pH units of the average, discuss possible problems with a GLOBE Representative.
6. Rinse the beaker or cup with distilled water and store for use the next time.

Measuring pH using a pH Meter

GLOBE Hydrology – Lesson 15b

<u>Note</u>: You can choose whether to use pH paper or a pH meter. The GLOBE Program accepts results from either.

<u>Note</u>: If you have a conductivity meter and know that the Electrical Conductivity of your water is greater than 200 µS/cm, you can skip the placement of salt into your testing sample. If need be, instructions for testing without the addition of salt are available through your GLOBE representative or at www.globe.gov under Hydrology Protocols.

Materials / Preparation:

- pH meter
- Hydrology Investigation Data Sheet
- Distilled water in wash bottle
- Soft clean cloth or toilet paper
- Electrical conductivity meter (optional) *(in Niger, the square plastic bottles made by CNES are best)*
- 100-mL beaker or small cup reserved for this test
- Salt crystals (2 mm in diameter) or table salt
- Stirring rod or spoon
- Latex gloves or clean plastic bags to wear over your hands in order to avoid contaminating the water sample
- Equipment necessary for the calibration of the pH meter including:
  - 25 mL of pH 7.0 buffer solution in a jar with a lid - this jar should be labeled pH 7.0
  - 25 mL of pH 4.0 buffer solution in a jar with a lid - this jar should be labeled pH 4.0
  - 25 mL of pH 10.0 buffer solution in a jar with a lid - this jar should be labeled pH 10.0

  <u>Note</u>: Each jar should have an opening large enough to allow the entrance of the pH meter into the jar.

Prepare the Sample

1. Fill in the top part of your Hydrology Investigation Data Sheet. In the pH section of the sheet, check the box next to 'pH meter'.
2. Put on latex gloves or clean plastic bags.
3. Rinse tweezers in sample water and dry with toilet paper.
4. Rinse the beaker or cup with sample water three times.
5. Fill the beaker or cup with about 100 mL of sample water
6. Using the tweezers, place two crystals of salt (about 2 mm in diameter) in the sample water. Do not touch the salt with your fingers as the oils and acids from your hands will change the pH of the water sample.

If you do not have salt crystals, fill this letter O (Times New Roman 20pt) two times with a single layer of table salt and pour it into the sample water.

Note: The salt helps the pH paper or the pH meter accurately measure the pH as the pH paper does not work very well if the conductivity of the solution being tested is less than 200µS/cm.

7. Stir thoroughly with stirring rod or spoon.

Test for Conductivity (optional)

1. If you have an electrical conductivity meter, measure the electrical conductivity of the treated sample water using the electrical conductivity protocol, *Measuring Electrical Conductivity.*
    - If the electrical conductivity is 200 µS/cm or higher, record the value on Data Sheet.
    - If the electrical conductivity is still less than 200 µS/cm, go back to step 6 above and repeat until you get a value that is at least 200 µS/cm before continuing.

Test with the pH Meter

1. Remove the cap from the meter that covers the electrode (the glass bulb on the pH meter).
2. Rinse the electrode on the meter and the area around it with distilled water from the rinse bottle. Blot the meter dry with a clean piece of cloth or toilet paper.

   Note: Do not rub the electrode with the cloth nor touch it with your fingers.

3. Rinse the electrode with distilled water and blot dry again.
4. Calibrate the pH meter according to the manufacturer's directions.
5. Put the electrode part of the pH meter into the treated sample water.
6. Stir once with meter. Do not let the meter touch the bottom or sides of the beaker. Wait for one minute. If the pH meter is still changing numbers, wait another minute, or until the numbers stabilize.
7. Record the pH value on the Data Sheet under Observer 1.
8. Repeat steps 3-14 using new water samples. However, skip step 4 as you do NOT need to calibrate the pH meter again. Record conductivity and pH values on Data Sheet as Observer 2 and Observer 3.
9. Rinse the electrode with distilled water and blot dry. Turn off the meter. Put on the cap to protect the electrode.
10. Calculate the average of the three observations.
11. Check to see if each of the three observations is within 0.2 of the average. If all three are within 0.2, record the average on the Data Sheet. If all three observations are not within 0.2, repeat the measurements. Calculate a new average. Check to see if all three observations are within 0.2. If they are, record the average. If they are not, talk to your GLOBE Representative about possible problems.

Hydrology Data Sheet

School name: ____________________ Name of Study Site: _________________________

Name(s) of Student(s) filling in Site Definition Sheet: _______________________________

Measurement Time:

Year: ______ Month: ______ Day: ______ Time (Local): ______ Time (UT): ______

Water State: (check one)

❑ Normal ❑ Flooded ❑ Dry ❑ Frozen ❑ Unreachable

Cloud Cover (check one):

❑ No clouds
❑ Clear (<10%)
❑ Isolated clouds (10%-24%)
❑ Scattered (25%-49%)
❑ Broken / Partially covered (50%-90%)
❑ Overcast (>90%)
❑ Obscured

Transparency Tube

Trial Number	Observer's Name	Depth (cm)	Greater than depth of transparency tube?	Average
1			❑ Yes ❑ No	_____ cm
2			❑ Yes ❑ No	
3			❑ Yes ❑ No	

<u>Note</u>: *If the image is still visible when the tube is full, input the length of the tube and then check "Yes" under "Greater than depth of the transparency tube".*

Water Temperature

Trial Number	Observer's Name	Temperature (°C)	Average
1			________ °C
2			
3			

Conductivity: Temperature of water sample being tested: ______ °C

Trial Number	Observer's Name	Conductivity (µS/cm)	Average
1			________ µS/cm
2			
3			

Conductivity of the Standard Solution used for calibration: ______ µS/cm

Water pH: Measured with (check one): ❑ paper ❑ meter

Trial Number	Observer's Name	Measured pH	Conductivity if known (µS/cm)	Average pH
1			________	________
2				
3				

Value of buffers used to calibrate pH meter: ❑ pH 4 ❑ pH 7 ❑ pH 10
(Check all of the buffers that were used)

Note: Data tables for the measures of salinity, alkalinity, and level of nitrates can be found along with those protocols in the International GLOBE Program Guide or on the web at www.globe.gov.